A study of local governments' challenges and processes in financing their greenhouse gas abatement initiatives

By

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Statement of Candidate

I certify that the work in this thesis entitled "**A study of local governments' challenges and processes in financing their greenhouse gas abatement initiatives**" has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis.

The research presented in this thesis was approved by Macquarie University Ethics Review Committee, reference number: 5201400296 on 26 March 2014**.**

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Glossary

Alternative energy project – Referring to project involving energy efficiency, solar PV, solar hot water, wind, co-generation and trigeneration.

Base Year - Year to which all cash flows are converted.

Benefit/Cost Ratio - The ratio of the SUM of all discounted benefits accrued from an investment to the sum of all associated discounted costs.

Clean energy – With the introduction of the Clean Energy Plan in Australia, this term is commonly used interchangeable with the renewable energy.

Constant Dollar Analysis - An analysis made without including the effect of inflation, although real escalation is included.

Current Dollar Analysis - An analysis that includes the effect of inflation and real escalation.

Discount Rate - The rate used for computing present values, which reflects the fact that the value of a cash flow depends on the time in which the flow occurs.

Internal Rate of Return IRR –The discount rate required to equate the net present value of a cash flow stream to zero.

Levelisation - Conversion of a series of transactions to an equivalent value per unit of output.

Levelised Cost of Electricity – LCOE The cost per unit of electricity that, if held constant through the analysis period, would provide the same net present revenue value as the net present value cost of the system.

Net Present Value NPV - The value in the base year (usually the present) of all cash flows associated with a project.

Opportunity Cost - The rate of return on the best alternative investment available.

Payback Period - The time required for net revenues associated with an investment to return the cost of the investment.

Discounted Payback Period DPB - The payback period computed that accounts for the time value of money.

Present Value PV - The value in the base year (usually the present) of a cash flow adjusted for the time-value differences in those cash flows between the time of the actual flow and the base year.

Sensitivity Analysis - The evaluation of a project under a number of different assumptions on the values of one or more uncertain variables.

Acronyms and abbreviations

A$	Australian dollar
$B	Billion dollar
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AETA	Australian Energy Technology Assessment
AGO	Australian Greenhouse Office
ALGA	Australian Local Government Association
ALP	Australian Labor Party
APVA	Australian PV Association
ARENA	Australian Renewable Energy Agency
ATA	Alternative Technology Association
BASIX	Building Sustainability Index
BREE	Bureau of Resources and Energy Economics
CBA	Cost Benefit Analysis
CCC	Committee on Climate Change
CCP	Cities for Climate Protection
CDO	Chief Development Officer
CEDA	Committee for Economic Development of Australia
CEFC	Clean Energy Finance Corporation
CEEP	Community Energy Efficiency Program
CEO	Chief Executive Officer
CO2-e	Carbon dioxide equivalent
CREST	Cost of Renewable Energy Spreadsheet Tool
CSP	community strategic plan
Cth	Commonwealth
DPP	Discounted Payback Period

EE	Energy Efficiency
ETS	Emission Trading Scheme
FSR	Financial Sustainability Rating
GDP	Gross Domestic Products
GHG	Greenhouse gas
GST	Goods and services tax
ICLEI	International Council for Local Environmental Initiatives
IEA	International Energy Agency
ILGRP	Independent Local Government Review Panel
IPCC	Intergovernmental Panel on Climate Change
IPART	Independent Pricing and Regulatory Tribunal
IRR	Internal Rate of Return
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt-peak
LCOE	Levelised Cost of Electricity
LED	Light Emitting Diodes
LG	Local Government
LGA	Local Government Area
LGSA	Local Government and Shires Associations of NSW
LNP	Liberal and National Party
LREC	Large Renewable Energy Credit
MWh	Megawatt hour
MWp	Megawatt-peak
NABERS	National Australian Built Environment Rating System
NEM	Australian National Electricity Market
NGS	National Greenhouse Strategy
NREL	National Renewable Energy Laboratory
NPV	Net Present Value
NSW	New South Wales

O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
pa	per annum
PV	Photovoltaic
RET	Renewable Energy Target
R&D	Research and Development
SREC	Small Renewable Energy Credit
SSROC	Southern Sydney Regional Organisation of Councils
TLCC	Total Life-Cycle Costs
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WALGA	Western Australian Local Government Association

Abstract

Local government has the potential to lead the transition from a high to low carbon economy. As a tier of government, it holds responsibilities for urban planning, building approvals, waste management, transport, street lighting and managing its own buildings and facilities. It is subject to the vertical interdependences with other tiers of government and horizontal pressure by its community for delivering services and facilities. Both factors directly impact on its financial capabilities and decision-makings.

This research has identified institutional capacity constraints as a major barrier to the investment in alternative energy projects. By examining the financial evaluation and alternative energy investment decision-making processes of five urban councils, it found: most of the initial financial assessments for alternative energy projects were undertaken by environmental staff in isolation from those with specific financial expertise and without accessible financial-evaluation tool; institutional and political leadership to achieve committed greenhouse gas emission targets is inconsistent; and the lack of national guidelines in tracking and reporting of alternative energy projects and emissions reduction progresses for the sector, which has rendered meaningful comparative analysis between councils and quantifiable aggregated-progress reporting impossible.

To address these constraints, a simple financial evaluation model was constructed to support investment decision-making process. This model included investment-criteria of NPV, IRR, discounted payback period and LCOE which are commonly used by financial managers in their assessment of medium to large capital investment decisions. A standardised national tracking and reporting platform is also recommended to enable local government in realising its potential as a leader in alternative energy investment and policy.

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1 Introduction

Climate change risks present an urgent need to transition the global energy market from its carbon-intensive focus to a renewable energy economy. Responsibility for this transition rests with many organisations including all levels of governments, energy providers, industries and the broader community. Local government is often associated as that being the closest to the community and can play an important leadership role in progressing the renewable energy transition. This is demonstrated through its own initiatives in powering community buildings, policy setting for planning and development and more recently in supporting alternative energy distribution networks. Local government is able to influence over 50% of greenhouse gas (GHG) emissions through its role in planning and development, waste management, land use, road infrastructure and street lighting (Lumb et al., 1994; Lumb et al., 1995; Commonwealth of Australia 1995; Lindseth, 2004). Through this case study project involving five councils, this research investigates the challenges and processes undertaken by the Australian local government sector in financing alternative energy projects and how these contribute to meeting their greenhouse gas abatement targets.

1.1 The challenge of global climate change mitigation

Mitigating the effects of climate change at the global scale has many uncertainties. This contributes to the challenges in quantifying risks and in turn economic impacts. Stern et al. (2006) estimated that the cost of actions to reduce global carbon emissions to avoid the worst-case scenario of climate change risk will be approximately 1% of global annual GDP.[1] According to Garnaut (2008), it would be a manageable 0.26 % of GDP or $2.8 billion in 2007 as Australia's global share that the Federal government could commit to spend in research and development and commercialisation of new low-emissions technologies. Despite the mitigating efforts adopted by many Kyoto ANNEX I[2]countries in the past decades, CO_2 emissions are still rising in tandem with the global economic activities propelled by energy

[1] GDP: Gross Domestic Product.
[2] **Annex I Kyoto Parties** are
Australia, Austria, Belgium, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco (included with France), the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, the Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Ukraine and the United Kingdom.

from fossil fuel (IPCC, 2014a). It is clear that a more coordinated strategic actions and long-term mitigation investment are needed at the international level and by individual nation states for climate change mitigation to have any affect (IPCC, 2014b). As noted by Stern et al. (2006), this is not the purview of one sector of government, but rather requires cooperation and coordination across multiple scales of government at international, regional, national and local levels.

The uncertainty in estimating the economic effect of climate change risk rests largely on how nations and their economies prioritise fossil energy reduction and speed in the transition to renewable energy production. Renewable energy plays a crucial role in this transformation, which needs supportive policy mechanisms in public finance to direct private investment in expanding trends for a sustainable future. The global trends in renewable energy investment fell for 2012–2013 to $214 billion from the peak of $279 billion in 2011, a 23% reduction (McCrone et al., 2014). The main reason for the decline was the effect of policy and economic outlook uncertainties in many countries which have discouraged the needed investment in the sector in developed and developing countries alike. Figure 1-1 shows the trend in total renewable energy investment worldwide by asset class. It clearly shows an easing in trend instead of the expansion needed to bolster the effect of global mitigation.

Australia, being both an industrialised country and a significant fossil energy (coal) exporter, has a responsibility both as a developed nation and an economic imperative to be in step with the rest of the world (CEDA, 2014).[3] The investment required to reduce GHG emissions is often capital intensive and requires appropriate policy certainty and incentives. Being a relatively small industrialised nation, Australia must be responsive to global developments in both the policy and economic environment on climate change risks, especially on how to best expend its natural resources. However, the lack of a political bipartisan approach to climate-change policy and the fragmented approach is definitely not conducive to the economic transformation required to bring Australia in line with international developments (CEDA, 2014). The impact of the recently repealed carbon tax on the economics of climate change is yet to filter through (Bumpus, 2014).

[3] The Committee for Economic Development of Australia.

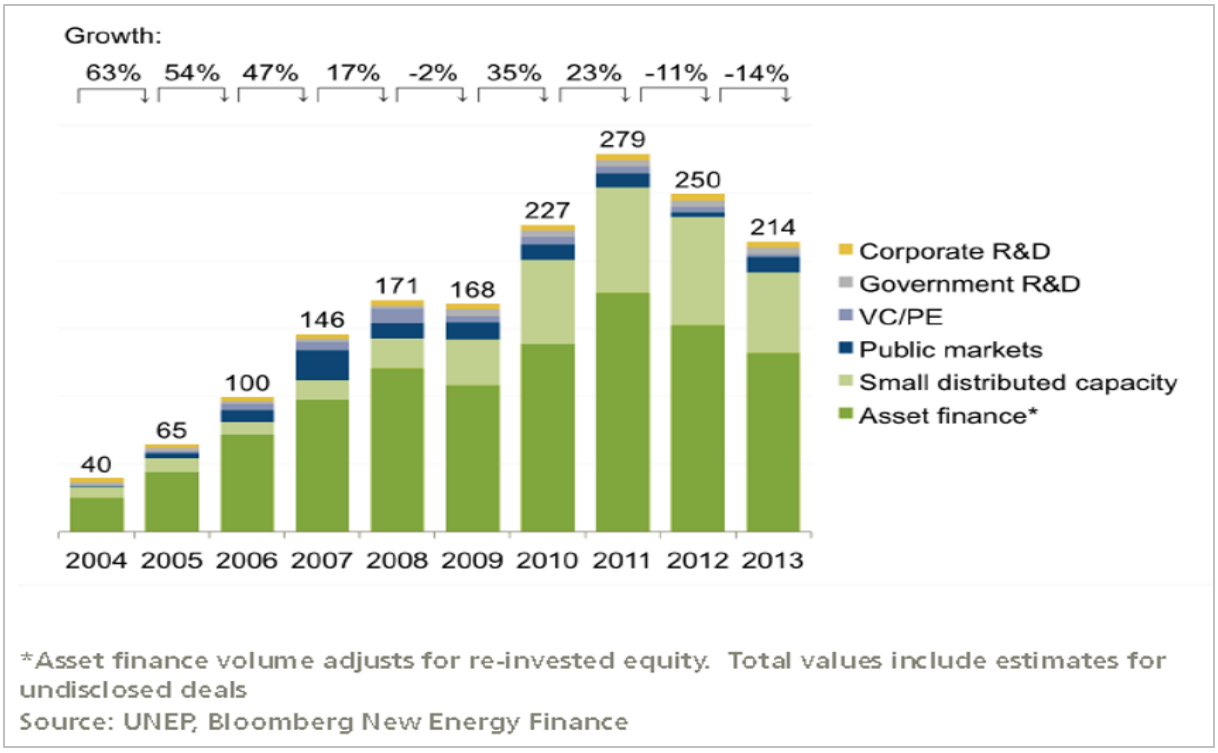

Figure 1-1 Global new renewable energy investment trend by asset class $B

1.2 Australia's Kyoto obligation

With the release of the National Greenhouse Response Strategy in 1992, Australia was one of the first countries to implement a national greenhouse response. The National Greenhouse Strategy, released in 1998, provided the strategic framework for advancing Australia's domestic response to GHG issues and prioritising coordinated national implementation and actions by all jurisdictions. Leading up to the Kyoto Convention in 1997, the Commonwealth Government committed almost $1 billion to the greenhouse response, encouraging a strong early voluntary action to reduce GHG emissions through a partnership approach with industry (the Greenhouse Challenge) and local government (CCP—Cities for Climate Protection™) (AGO, 1999).

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC) which commits its ANNEX I Parties to set internationally binding emission reduction targets. It was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005 (UNFCCC, 2014). Being one of the ANNEX I Parties, Australia signed the Kyoto Protocol on 24 April 1998, but did not ratify it until December 2007, following the election of the ALP government. Given Australia's unique emissions profile, which is closely linked to major trading in resources and carbon-intensive energy commodities (such as coal and iron ore export), its first target was to limit emissions to 108% of 1990 levels in the first commitment period from 2008 to 2012 (Commonwealth of Australia, 2000). The second unconditional bipartisan-agreed Kyoto target of 5% below 2000 levels to be achieved by 2020 for the second commitment period was announced in December 2012 (Dept. of Environment, 2007; 2012). To achieve the committed Kyoto obligation, the Commonwealth Government under the Labor Party had set the national Renewable Energy Target (RET) to be 20% of power comes from renewables by 2020 (Commonwealth of Australia 2011a, 2011b) and was strongly supported by the NSW State Renewable Energy Action Plan (NSW Government, 2013a).

1.3 The role of local government

The Kyoto protocol requires the federal government to develop and implement an effective national strategy and policy to reduce GHG. An effective strategy would be best to focus on decarbonising the fossil-intensive energy sector, especially the coal-based electricity supply to cities. Since approximately 70% of carbon emissions arise from energy use in cities, and 41% of the emission comes from the electricity sector (UN-Habitat, 2011; Van der Hoeven, 2012), local government has been identified as a sector of government having direct control over 50% of emissions through its operations, regulatory roles and land-use planning. This has rendered the local government sector as a critical player in the GHG reduction strategy of the nation.

Action on climate change magnifies jurisdictional complexity, as both actions and impacts cross local, state and national boundaries (Howes 2005; Ross & Dovers 2008 cited in Howes et al., 2013, p. 3). In spite of this governance structure, local government has provided some of the most innovative and consistent leadership and action on climate change. This has been delivered in spite of many barriers, as described by Brackertz (2013) and others, including:

- Lack of constitutional standing in which local government is a creature of and dependent on their respective state government.
- Intergovernmental dependencies for financing which cause the financial constraints that are particularly acute in NSW due to rate capping (Pricewaterhouse Coopers, 2006; Treasury Corporation, 2013).

- Devolved responsibilities from both federal and state governments and perceptions that the local government sector must continue to fulfil its traditional obligations as a priority, which are often described as roads, rates and rubbish as reported by Mananauskas (2013).
- The expectation to also show leadership in many other environmental and social endeavours (Wild River, 2006; Allender et al., 2009).

The vertical interdependencies and hierarchy affecting local governments and the horizontal pressures for resources and the delivery of infrastructure and services provide a unique setting in which to explore how internationally critical programs, such as climate change, are delivered by arguably the level of government least able to fund mitigation efforts. This research will uncover the specific challenges and barriers and the financial evaluation tools used by five urban local councils in NSW to examine how they prioritise their climate change mitigation initiatives.

1.4 Aims and objectives of the study

The initiation in 1997 of the International Council for Local Environmental Initiatives (ICLEI)'s CCP program by the Federal Government, was a catalyst for commencing action on climate change by local government (Bulkeley, 2000). Funding from the CCP program and other federal and state grants enabled the capital investment in climate change mitigation projects that aimed to achieve the local governments' emission reduction targets (SEDA, 2004; Bulkeley, 2010). Reporting on emission reductions by the sector has been mixed, particularly since the ending of the NSW States' Sustainable Energy Development Authority program in 2004 (SEDA, 2004) and the CCP program in 2009 (Pillora, 2011). Without further funding assistance from the higher tier of governments, the ongoing known financial and institutional capacity constraints on the NSW local government sector (Dollery et al., 2006; LGSA, 2006; Atkinson et al., 2007; Pillora, 2011; Storey et al., 2012; ILGRP, 2013; Carter, 2013; Dollery, 2014) would likely have negative impact on their ability to progress their climate change mitigation policy agenda. Under such circumstances, the financial decision-making processes on choosing the best projects in which to invest that could maximise the result on emission targets has become critical, but remains largely unknown.

This research provides an in-depth case study of five urban councils in the Sydney metropolitan area. Through close investigation of the economic decision-making processes of how their GHG abatement energy projects were evaluated and financed, this study aims to answer the following questions:

1. What emission mitigation targets were set, and how were they accounted for and monitored in tracking progress?
2. What is the priority of the climate change mitigation policy in the councils' operation and what is the impact of the financial sustainability on the decision-making regarding the target and priority?
3. What are the challenges and barriers in mitigating the local emissions:
    a. From an institutional capacity perspective
    b. From National Electricity Market (NEM) regulation perspective?
4. What financial evaluation processes were adopted in ensuring the economic viability of the alternative energy projects and if the accounting of the projects' performance was tracked and aggregated?

From this analysis the research will construct a financial evaluation model relevant for the local government sector to inform and improve their investment decisions on alternative energy projects.

Due to the time constraints of the project, this research is limited to investigating energy demand management, including energy efficiency (EE), street lighting retrofit initiatives, and supply management options, including the rooftop solar photovoltaic (PV), solar heat pump and gas co-generation or tri-generation projects. The remainder of the thesis is set up as follows. Chapter 2 provides a review of the literature and presents the history and background of the local governments' involvement in climate risk mitigation, and their challenges and barriers, including economic evaluation theory and framework. Chapter 3 provides the methodology applied in the thesis. In particular, it describes the mixed method, data collection and analysis processes design and approach in constructing the financial evaluation model with measuring criteria and calculation formula. Chapter 4 presents all the discoveries and analyses of both quantitative and qualitative results. Chapter 5 provides a brief discussion of the results, followed by recommendations. Chapter 6 presents the constructed financial model. Two case studies of the solar PV projects from the City of Sydney and Willoughby councils are used to demonstrate the calculation results and sensitivity analysis of various variables used in the model. Chapter 7 concludes and provides suggestions for future research.

2 Literature Review

2.1 Climate Change Governance in Australia

2.1.1 The Australian political system

Australia has a three-tiered political system consisting of the federal, state and local governments. The balance of political and legal power, economic influences and responsibilities is set by the constitution and various federal and state laws. Local government is not recognised in the Australian Constitution and thus is a creature the State Parliaments (Aulich and Pietsch, 2002). The early functions of local government were directed to public health and safety, particularly around sanitation, and managing various low-key public assets. These responsibilities have been gradually increased, shifting from a regulatory-dominated role to that of having a major role in planning and development and proving a broad range of community and environmental services (Aulich, 1999; Kelly, 2011).

The powers, functions and responsibilities of local councils are set by the respective states (for example, the *Local Government Act 1993,* NSW). Supporting the primary Act of Parliament that creates local government as a legal entity there are many other pieces of legislation that outline various powers and functions for councils (Stilwell and Troy, 2000; LGSA, 2006; Thomas, 2010; ILGRP, 2013). Local government as a sector has been the subject of many reviews and inquiries (Carter, 2013; Tan & Artist, 2013; Gooding, 2013), and areas for reform and improvement have not always been implemented, often due to the political or other motivations of those initiating or having to implement the review. In NSW, the most recent review by a state-appointed independent panel has made many recommendations to strengthen the long-term position of local government. This is in response to various pressures, particularly the increase in responsibilities devolved from other tiers of government; financial constraints; the longer-term sustainability and ability of smaller councils to meet community needs and expectations; the anticipated impact of climate change; and the decline in specific-purpose grants that, for example, focus on climate change and alternative energy (ILGRP, 2013). The NSW Independent Local Government Review Panel (ILGRP) report is yet to be acted upon.

Given the global nature of the problems related to climate change, international obligation to the ratified commitments will not be achievable without explicit engagement with support to the states and local government. From a planning and land use perspective, there are several direct and indirect policies by federal and state governments that will affect the capacity of local governments to reduce GHG emissions in their local area and, in turn, the state and nation (Betsill and Bulkeley, 2006). In the United Kingdom, for example, some councils are pursuing decentralised and alternative energy systems that reflect what is perceived as an implicit core function along with waste, transport and planning. This also corresponds to a shift towards localism in decision-making and prioritisation for local facilities and services (Bale et al., 2012). Local authorities in the UK were recognised as having a crucial potential that could significantly affect the UK's scale and speed of emissions reduction in reaching its ambitious carbon emissions targets (CCC, 2014).

2.1.2 The initiation of the CCP Australian Program

Leading up to the Kyoto Convention in 1997, the federal government provided funding of A$13 million over five years for the CCP program through ICLEI's CCP campaign (Bulkeley, 2000). To participate in the CCP program, the councils had to adopt a Local Government Resolution to ensure that political commitment was established at the commencement of the program. Then the member councils had to agree to complete the five ICLEI standard performance-based milestones (ICLEI, 2003):

(1) Conduct an inventory;
(2) Establish a goal;
(3) Develop the Local Action Plan;
(4) Implement policies, plans and measures;
(5) Monitor and verify results.

Between 1997 and 2009, 238 councils joined the program (Pillora, 2011). Most councils set emission reduction targets for their own area or operations in line with already agreed federal or state policies. Other more ambitious councils set a more ambitious agenda and committed to milestones and targets exceeding the nationally agreed limits as an indicator of their commitment to the seriousness of this issue (Bulkeley, 2000; Pillora, 2011).

The federal support to the CCP program was not just motivated in raising its climate governance visibility globally while negotiating for a favourable Kyoto emission outcome for the nation. The federal government had also demonstrated its understanding and recognition of Australia's regional diversity and the capacity for different governments to pursue an effective greenhouse response through different policy by encouraging early voluntary action through the CCP Australian Program (AGO, 1999). It was also considered to be a simple initiation process of implementing the bulk of climate change policies by engaging and devolving to the local governments for the policies to be effective and more capable in dealing with the dynamics of individuals, households and communities (Bulkeley, 2000; Storey et al., 2012).

At the conclusion of the CCP Australian Program in June 2009, ICLEI reported that 18 million tonnes of CO2-e (carbon dioxide equivalent) were saved by local government participants (based on 1998/99 reporting). The abatements were mainly through councils' actions in reducing their corporate emissions from their buildings, street lighting, vehicle fleets, water, waste and sewerage operations. Even though the loss of this program was supported by a $25 million Local Government Reform Fund aiming at building local government capacity through collaborative projects, it has inevitably left a significant gap for a number of new member councils: there was no proper organisation established to provide supporting services, such as the inventory, planning, implementation and emissions reporting functions formerly covered by the CCP program on a national scale. The Australian Local Government Association (ALGA) National General Assembly 2009 communiqué had advocated the reinstatement of funding for the program without success, hence the gap still remains (Pillora, 2011).

2.1.3 The Clean Energy Future for Australia

Following the Garnaut report in 2008 (Garnaut, 2008), the federal government approved a Climate Change Plan, 'Securing a clean energy future' (Commonwealth of Australia, 2011b). Accompanying the Climate Change Plan was the *Clean Energy Act 2011* (Cth) that brought into law a commitment to reduce carbon emissions by 5–25% from 2000 levels by 2020, subject to the scale of global actions, and a long-term target of 80% from 2000 levels by 2050. The four main elements of the Clean Energy Plan included a carbon price, renewable energy, energy efficiency and action on the land (Commonwealth of Australia, 2011a; 2011b).

The *Clean Energy Act 2011* (Cth) also established the governance structures to oversee and assist in the implementation of the clean energy plan. These included the Climate Change Authority and Clean Energy Regulator as well as the transition-supporting institutes like the Clean Energy Finance Corporation (CEFC) and Australian Renewable Energy Agency (ARENA) (Commonwealth of Australia, 2011a). A combined funding of $13 billion from federal government was provided for CEFC and ARENA over five years for stimulating R&D, commercialisation and assisting private investments in clean energy technologies, as well as facilitating the growth and sharing of knowledge and information on clean energy technologies (CEFC, 2012; ARENA, 2012). Under the national Clean Energy policy framework, states were quick to follow and develop complementary climate policies and action plans in support of the national Renewable Energy Target (RET) (NSW Government, 2013a). By enhancing the energy efficiency rating standard such as Building Sustainability Index (BASIX) and National Australian Built Environment Rating System (NABERS), the energy efficiency program funded by the Energy Savings Fund of $22.9 million from the NSW state government provided support for energy savings from high energy users and local councils in NSW to prepare and implement their energy savings action plans (NSW Government, 2013b).

2.1.4 The impact of political polarisation of climate governance

Since the initiation of the ICLEI's CCP program in 1997 many councils obtained financial assistance to build their capacities in setting and carrying out the emission reduction targets. The implementation of alternative energy projects was also boosted by additional funding from the federal and state governments. However, at the national level, Australia's governance to climate actions over the past three decades has been judged as inconsistent and lacking in commitment and direction (Talberg et al., 2013). The climate policy at the national level has been polarised to be a highly contested political issue, resulting in erratically altered courses such as disbanding the climate-change governing bodies, creating new ones, then dismantling them again (Talberg et al., 2013). This is due to the considerable differences of the climate policies between the two major Australian political parties, the Australian Labor Party (ALP) and the Liberal and National Party (LNP).

Both the ALP and LNP had both advanced and regressed on their climate policies when they were in government (Talberg et al., 2013). For example, in 1990 when the ALP was in government, it resisted adopting an emissions reduction target canvassed by its own Minister for Environment, only accepting with a proviso which rendered the target ineffectual. Yet the ALP Government is also responsible for the current Australia's 2020 emissions reduction targets. Likewise, the LNP Government insisted in 1997 that adopting targets would have a 'devastating impact' on jobs and industry. However, it had brought commendation to Australia in 1998 by creating the Australian Greenhouse Office, which was the world's first government agency dedicated to reducing GHG emissions. The current issue of political contention is Australia's Emission Trading Scheme (ETS) to follow the carbon tax: the LNP Government repealed the carbon tax in July 2014, leaving the ETS future in doubt (Hopkin, 2014). However, in 1999 the same party had demonstrated a strong support of ETS with the commissioning of four discussion papers on emissions trading (Talberg et al., 2013).

2.1.5 The consequence of uncertainties

With the repeal of the carbon tax, the Climate Change Plan policies which had made progresses and created momentum in the uptake of the clean energy since its implementation under the former ALP Government are currently under review by the LNP Government. Undoubtedly, these frequent changes linked to electoral cycles and the current instability in federal and state politics have failed to provide the certainty needed in inducing and mobilising long-term capital investment for renewable energy technologies and the growth of industry (Simpson and Clifton, 2013). As a result of the general lack of strong bipartisan political agreement on a long-term national climate governance framework at the top tier of government, Australia is ranked as the highest per capita emitter in the world (Commonwealth of Australia, 2011b p. 12; Flannery et al., 2013 p. 30), despite electricity emissions having decreased as a result of a 5% reduction in electricity demand from 2009 to 2013 and renewable energy is currently generating over 12% of all electricity in Australia (ClimateWorks, 2013).

2.2 Challenges confronting local governments

2.2.1 Financial constraints of NSW local governments

The operational funding source for NSW local governments is made up of a combination of property taxes such as rates, charges and fees for services, intergovernmental grants and various other minor sources (Dollery et al., 2006; IPART, 2009; Comrie, 2013). On average, councils raise around 36% from rates income; sales of goods and services contribute 24%; and grants and subsidies make up about 12% (Carter, 2013). The most acute problems confronting Australian local governments in general derive from the fiscal pressures. The fiscal stress is more critical with those smaller rural councils that have less capacity than their urban counterparts in raising own revenue sources (Comrie, 2013). The Commonwealth Grants Commission (Commonwealth of Australia, 2001, pp. 52–53) identified five main reasons for financial distress in Australian local government as follows:

1. *Devolution* –where a higher sphere of government gives councils responsibility for new functions
2. *Raising the bar* – where a higher level of government, through legislative or other changes, raises the complexity and/or standard for councils' service provision, thus escalating the cost of service provision
3. *Cost shifting* – either when councils agree to provide a service on behalf of the federal or state government with funding subsequently reduced or cancelled; or when some other tier of government ceases providing an essential service, thereby obliging councils to deliver the service
4. *Increased community expectations* – where a local community demands improvements in existing local services or the provision of a new local service
5. *Policy choice* – local councils voluntarily expand and/or improve their service provision.

The financial stress of local governments is even more acute in NSW partly due to the close control from the state government with rate pegging exerted through the Independent Pricing and Regulatory Tribunal (IPART) (IPART, 2009), partly due to their reluctance in raising rates as well as setting fees and charges at more realistic levels (ILGRP, 2013). As a result, funding of the local government systems in Australia for the past 30 years has been falling further relative to other tiers of governments, with various adverse consequences (Dollery et al., 2006; LGSA, 2006). One of the consequences is a $14.5 billion infrastructure renewals backlog and an annual underspend on asset renewals of about $1.1 billion per annum, as reported by the National Financial Sustainability of Local Government Report (LGSA, 2006). With a huge infrastructure backlog in the local government arena, the climate change governance in Australia has brought to bear the question of how financially sustainable the many councils are in managing their 21st century climate risk challenges. (Dollery et al., 2006; Carter, 2013; Dollery, 2014). In light of these issues and concerns, there is a proposal for structural reform aimed at revitalising the institutional capacity and fiscal sustainability of local government (Dollery, 2005; ILGRP, 2013; Dollery, 2014).

2.2.2 Institutional capacity constraints

There are many definitions of institutional capacity and for the purposes of this research we adapt this definition conceptually from De Vita & Fleming (2001) and Chaskin (2001). The institutional capacity is referred to as the ability of an organisation to fulfil their goals in an effective manner. The dimensions of the ability of an organisation are the aggregate of its *leadership*, *financial resources*, *skills and competencies* of the people participating in taking courses of action that can overcome obstacles to achieve a chosen goal or vision for the organisation.

The standard performance-based milestones of the CCP Australian Program had helped its member councils build the skills of setting goals against their carbon inventory, developing local policy and action plans, and monitoring and measuring their results against their chosen goal (ICLEI, 2003). The processes of achieving these milestones had enabled a few strong member councils (such as Melbourne City Council and City of Sydney Council) to exercise their autonomy in devising and implementing ambitious local climate change mitigation targets exceeding the national RET. However, Pillora (2011) reported that the lack of capacity and resources of many councils inhibited their capability to do everything that is required of them in achieving their emission targets.

Councils that have the capacity dimensions described above can adopt many approaches in reducing their emissions across all sectors of their energy end-use, including electricity, buildings and street lighting retrofits, transport and waste treatment (Bulkeley, 2010).

However, many of them lack such capacity dimensions; hence are mostly limited to engaging in renewable energy target setting, energy efficiency efforts and green local government procurement standards. Energy efficiency in particular is the most common initiative that councils can adopt for their own properties and operations as well as the development of enabling activities to promote action in their communities and businesses (Atkinson et al., 2007; Pillora, 2011; Storey et al., 2012).

Lying at the crux of the institutional capacity constraints of the councils are the above mentioned political, revenue and fiscal structural imbalances that affected their fundamental dimension of financial resources. This systemic lack of financial resources had a profound impact on the councils' ability to build other dimensions as required for achieving their chosen goals. The Fiscal Star report in 2009 rated three of the five participating councils of this study as financially 'sustainable', whereas the other two were rated as 'vulnerable' and 'unsustainable' (Fiscal Star, 2009). More recent research from the NSW Treasury Corporation has shown that 52% of councils were rated as 'moderate', which means they were likely to have recorded some minor to moderate operating deficits or a significant operating deficit. The report rated three of the five councils taking part in this study as 'moderate' and only two were in the 'strong' and 'sound' categories of the Financial Sustainability Ratings (FSR) (Treasury Corporation, 2013).

2.2.3 Electricity market barriers

2.2.3.1 Obstacle to genuine sweeping reform of NEM

Energy policy in Australia reflects a combination of constitutional responsibilities, intergovernmental agreements[4] and market agreements. Different priorities among governments result in an incentive structure that leads to socially and economically suboptimal decisions (Byrnes et al., 2013). The state government of NSW owned seven corporations involved in generating, transmitting and distributing electricity in the State (see Figure 2-1) (NSW Auditor-General, 2012). This can result in divergent incentives and motivations for policy amendment and intervention. This complexity has led to conflicting policy and onerous compliance requirements for electricity market participants and made it difficult for new participants and technologies to be integrated (Byrnes et al., 2013). The NSW

[4] Mainly between the state and federal governments.

Auditor-General (2013) reported the financial benefit distribution in 2013 to the NSW Government from their electricity entities amounted to $1.4 billion, comprising $487 million in taxation and $913 million in dividends. This has offered a clue of the real obstacles to a sweeping reform needed in Australian National Electricity Market (NEM) market in encouraging more investments in the renewable energy adoption, both from the private sector and local government perspectives.

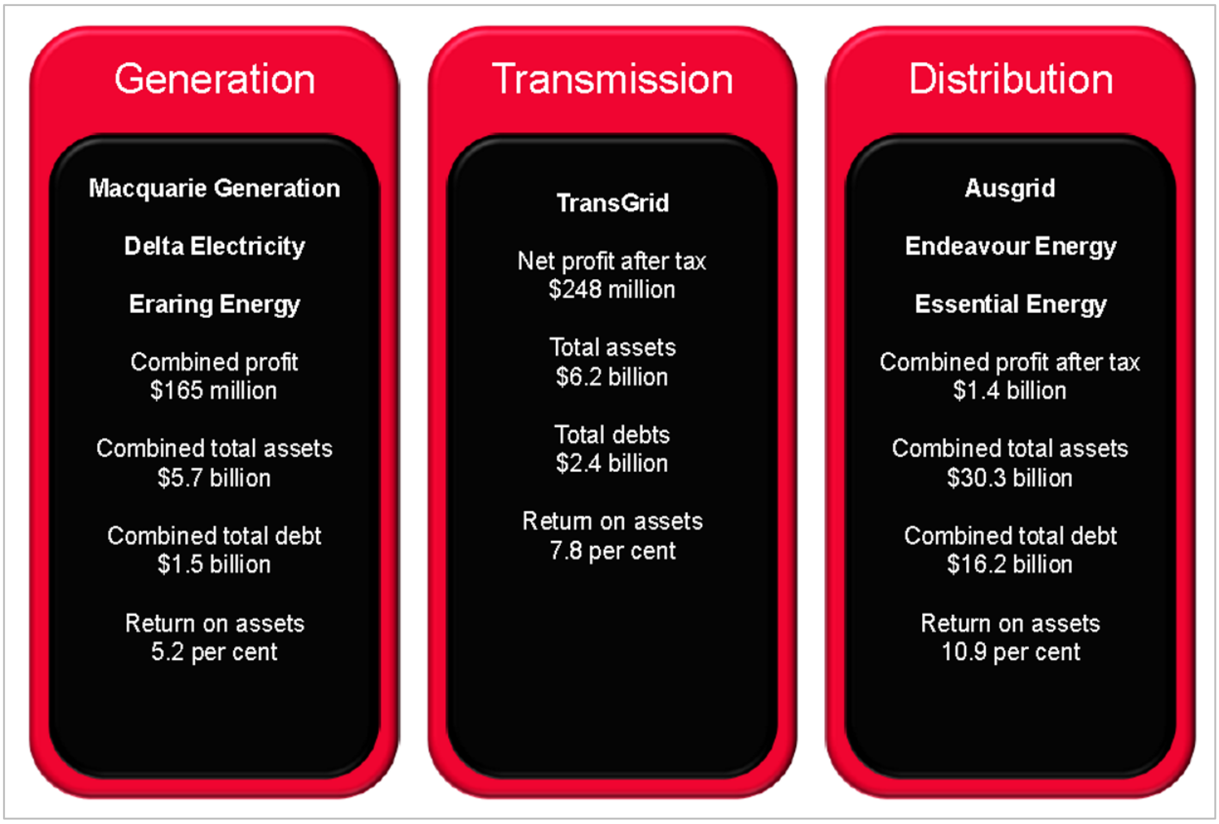

Figure 2-1 Seven state-owned energy corporations. Source: NSW Auditor-General Electricity Industry Overview 2012-13

Apart from the implicit financial dependency of the state government on revenue from the traditional energy corporations, NEM is also a very dynamic and complex deregulated electricity system made up of four sectors: generation, transmission, distribution, and retailers. The market is currently regulated by governing bodies such as the Australian Energy Market Commission (AEMC), Australian Energy Regulator (AER), Australian Energy Market Operator (AEMO) and IPART. The complexity in the NEM market is a consequential struggle for vested benefits from interactions among many groups of stakeholders and actors with intertwining conflicts and interests (Byrnes et al., 2013). With the web of market complexity and rising energy costs, consumers, including residential, industrial and institutional, like the councils, must negotiate their positions by way of energy conservation and renewable energy adoption. The cost of grid connection and the current feed-in tariffs structure (IPART, 2014) have a negative impact on the financial feasibility of renewable energy projects that have a high feed-in consumption pattern.

2.2.3.2 Obstacles facing the local governments in street lighting

There are approximately 2.28 million street lights in service in Australia, with an annual cost of electricity exceeding $250 million, which is the single largest source of GHG emissions from local governments, and typically accounts for 30–60% of their emissions (Commonwealth of Australia, 2011c). The barriers of improving the EE of the street lighting lie in the ownership of the majority of infrastructures by various energy distributors and retailers, whereas the costs of electricity and maintenance are covered by the councils.

In the state of Western Australia, despite their willingness to commit to emissions and energy reduction actions, local government found the capital costs of broad and accelerated street lighting infrastructure upgrade to be prohibitive due to being locked-in to a 'non-contestability' contract with a single public lighting provider and operator [5] (WALGA, 2011). In the eastern states, even though it is financially viable to retrofit the street lights, the lengthy and complex processes involving negotiations and engagements with many large distribution companies, state and national regulators, and manufacturers can take time and induce frustration (Commonwealth of Australia, 2011c; 2012). The Street Lighting Improvement Program of the SSROC[6] is a showcase for the lengthy complex processes that have frustrated councils' collaboration efforts intending to achieve significant cost-saving and GHG emission reduction (SSROC, 2011; 2014a; 2014b).

To overcome the balance of power that is weighted towards the energy provider rather than the customer, local government can join forces to negotiate more favourable contracts and conditions (Ironbark, 2012). Brown (2014) reported their work in helping 11 Victorian councils gain funding from the Community Energy Efficiency Program (CEEP) in 2012 for street lighting projects in Round One of the Federal Department of Industry program. Then another 39

[5] Western Power owned 90% of Western Australia's public lighting infrastructures.
[6] Southern Sydney Regional Organisation of Councils.

Victorian councils were successful in Round Two in mid-2013. The CEEP provided funding for energy-efficient lighting bulk change projects. The aggregation of projects results from these two rounds of the regional partner of councils demonstrate that a pathway to success can be achieved through strengthened negotiation power by the economies of scale (Ironbark, 2012).

2.2.4 The challenges of economic and financial evaluation

The economic and financial analysis and evaluation of alternative energy projects demand a certain level of expertise and knowledge that requires a deep understanding of a wide variety of technologies as well as of the concept of economic, financial and environmental values (Short et al., 1995). The objective of an economic analysis is to provide the crucial information needed for making a sound investment decision. The process of the economic evaluation on an investment in a technology project requires the analysis of all annual direct, indirect and overhead costs, taxes, and returns on investment, plus any externalities such as environmental impacts over the life of the investment. However, the analysis has to be carried out in perspective within a defined framework of the purpose and scope at the outset, as that will influence the level of detail undertaken (Short et al., 1995; NSW Treasury, 2007).

The literature review has identified a gap in knowledge of economic and financial evaluation at the local government sector, which in general is a lack of large scale alternative energy projects of over a million dollars in value. However, there are approaches offering economic evaluation guidance and frameworks and/or financial models covering utility scale and large alternative energy projects, such as Short et al. (1995), NSW Treasury (2007), IEA-OECD (2010) and BREE (2013). Such guidance and frameworks often encompass the fundamental concepts of the difference between economic and financial evaluation, time value of capital costs and cash-flows in relation to the discount rate, as well as the adoption of the financial measuring criteria. The commonly used financial measuring criteria are the net present value (NPV), discounted payback period (DPP), internal rate of return (IRR) and levelised cost of electricity (LCOE) (Myers, 1984; Stulz, 1990; Ross, 1995; Lefley, 1996; Vanhoucke et al., 2001; Kelleher and MacCormack, 2004; Magni, 2010; BREE, 2012).

2.2.4.1 The difference between economic and financial evaluation

Economic evaluation considers the costs and benefits associated with a project from the perspective of society, whereas financial evaluation considers those factors only from the perspective of the investors (Woodruff, 2007). The traditional financial analysis examines a project from a narrow perspective of the entity, and does not consider the effects on other enterprises (NSW Treasury, 2007). Thus, a proposed project by one government agency may inflict costs or confer benefits on other government agencies, or on the private sector. These are considered to be external costs and benefits, which must be taken into account in an economic analysis. The carbon tax is an example of valuing the external cost of carbon-intensive fossil fuel technology when analysing a renewable energy project. Hence, the scope of economic evaluation is wider in comparison to the financial evaluation. As the financial analysis only considers the direct monetary values associated with capital and operating costs of a project (Short et al., 1995). A project is considered to be financially viable when its revenues exceed its costs. Economic evaluation considers both the monetary and non-monetary as well as the internal and external costs and benefits of a project. In this sense, a project that is economically viable may or may not be financially viable, and vice-versa (Woodruff, 2007).

2.2.4.2 The concept of the discount rate

The discount rate is to measure the time value or cost of money of an investment. The discount rate brings the value of investment costs incurred and benefits accrued over time in a long duration of an investment lifecycle to the present value for a unified comparison. The choice of discount rate is important to financial analysis and is influenced by a wide variety of factors that reflect the investor's rate of return, cost of capital, inflation rate, opportunity cost and risk premium (Short et al., 1995). Time value acts as a measure that reflects the waiting of an investor for a return on capital and it is central to the calculation of the present value. There can be a choice of a nominal discount rate for the current dollar cash flows that includes the inflationary effects and a real discount rate for the constant dollar that excludes inflation for the calculation in a financial model (Short et al., 1995).

2.2.4.3 *Cost Benefit Analysis and measuring criteria*

Different measures of economic and financial viability are used by different investors and for various types of investments. The Cost Benefit Analysis (CBA) is a principal economic evaluation technique adopted throughout the world in facilitating crucial investment viability decision-making (NSW Treasury, 2007; European Commission, 2008; US-EPA, 2010). In order to analyse the economic feasibility of a project, both the costs[7] and the benefits[8] that can be expressed in monetary terms are estimated and aggregated accordingly. They are then discounted with a discount rate for the life of the asset to obtain the NPV. The value of NPV, together with other measuring criteria such as the DPP, IRR and LCOE, are analysed and considered to provide an important appraisal results to inform a sound investment decision (NSW Treasury, 2007).

2.3 Conclusion

Storey et al. (2012) reported that, whilst many councils had carried out greenhouse mitigation plans and reported emission reductions in their communities, there is no nationally coordinated program, which has resulted in differing approaches being developed and used by individual and groupings of councils to measure and manage their climate change actions. Currently, there is also no consistent guide to assist in undertaking financial evaluations to assist in sound decision-making on investments for climate change mitigating projects or for keeping track of the financial performance outcomes from such investments. The above-mentioned financial and institutional constraints are limiting councils' ability to measure their own environmental performance in reducing greenhouse gas emission in relation to the financial performance of those mitigation projects. Hence, climate change actions by local councils have not been aggregated and reported nationally as evidence for the extent that their efforts are having a significant impact on national emissions (Storey et al., 2012). In light of the scarcity of the national GHG mitigating data at local government level, this research is carried out as an in-depth case study of five urban councils in Sydney. Through close investigation of the process of how their greenhouse gas abatement energy projects were evaluated and financed, this study aims to provide evidence-based answers to the four guiding questions listed in the 'Introduction' section.

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[7] Including the capital and operating cost.

[8] Including revenue, cost-saving and benefits to users and community.

3 Methodology

This research study is suitable to be carried out in the Action Research methodology. However, the vigorous involvement of the researcher and the participants, and the lengthy iterative looping processes in testing the viability of the constructed model through participation, lesson-learnt, modification and retesting are impossible to be achieved for the project of only eight months duration. Given an in-depth demand of examining the detailed financial evaluation and decision-making processes, there is also a limitation on the number of participants. Under such circumstances, a case-study methodology appears to be well-suited to deliver this study on time and on target.

To gain an insight into the challenges faced and the processes undertaken by local government in financing greenhouse gas abatement projects, a preliminary desk-top research was conducted. The aim was to find councils with these criteria: previously the members of the ICLEI's CCP program; had achieved the five milestones within the CCP program; had demonstrated an ongoing commitment to climate change mitigation planning and alternative energy programs; had completed a number of alternative energy projects. The initial analysis was based on website information and found only a few urban councils that can fulfil all the criteria. As a result, the rural councils with more financial constraint as revealed in Section 2.2.1 were deemed to have less chance of making these criteria and hence were not to be investigated for this study. The analysis had shortlisted eight councils to be invited to participate in the study. The invitation outlined the commitments anticipated and an indication of the data that would be required for the research study. Five councils accepted this invitation: Bankstown City, City of Sydney, Ku-ring-gai, North Sydney and Willoughby councils.

3.1 Mixed Methods

A mixed-method strategy with an appropriate combination of quantitative and qualitative methods and modes of analysis was used to inform the four research questions posed in the 'Introduction' section. The strength of mixing quantitative and qualitative research is to provide a more comprehensive answer to different research questions. When the two are conducted in tandem, the potential of new emerging outcomes is multiplied (Bryman, 2006). The discussions on combinations of both qualitative and quantitative approaches in Creswell

(2003) and Bryman (2006) provide the basic strategic design framework for this research. At the multi-strategy research designing phase, the processes of data collection, data analysis and interpretation were considered on how the quantitative and qualitative data were to be mixed in terms of their equal or dominant status, sequential or concurrent time sequence and mixing data fully or partially (Creswell, 2003; Bryman, 2006; Hall & Howard, 2008; Heyvaert et al., 2013).

3.1.1 Design of data collection and analysis processes

The data collection process of the study is an ‘‘exploratory sequential design’’ because information from the survey informed the interview questions and then the desktop research data collection. The data analysis process uses ‘‘convergent concurrent design’’, since the three data sets are analysed separately, then together, and then mixed in the interpretation stage (Creswell & Plano Clark, 2011). The theoretical orientation is interpretive. The relative priority of data sets is ultimately determined at the data interpretation and presentation stages of research rather than at the design phase as discussed by Guest (2013). Throughout the study, there were three sequential stages of data collection in the succession of survey questionnaire, semi-structured interview and desktop websites data collection. These were followed by two successive stages of data analysis, where the first stage was a preliminary analysis and findings to be presented to participants in Focus Group for feedback, then all feedback data was integrated for further analysis before final inclusion in the thesis. In parallel to the first stage of data analysis, a financial evaluation model was constructed, based on the data collected and analysis, that is presented together with the preliminary findings in the Focus Group. Figure 3-1 shows the flow of data collection process and analysis process stages.

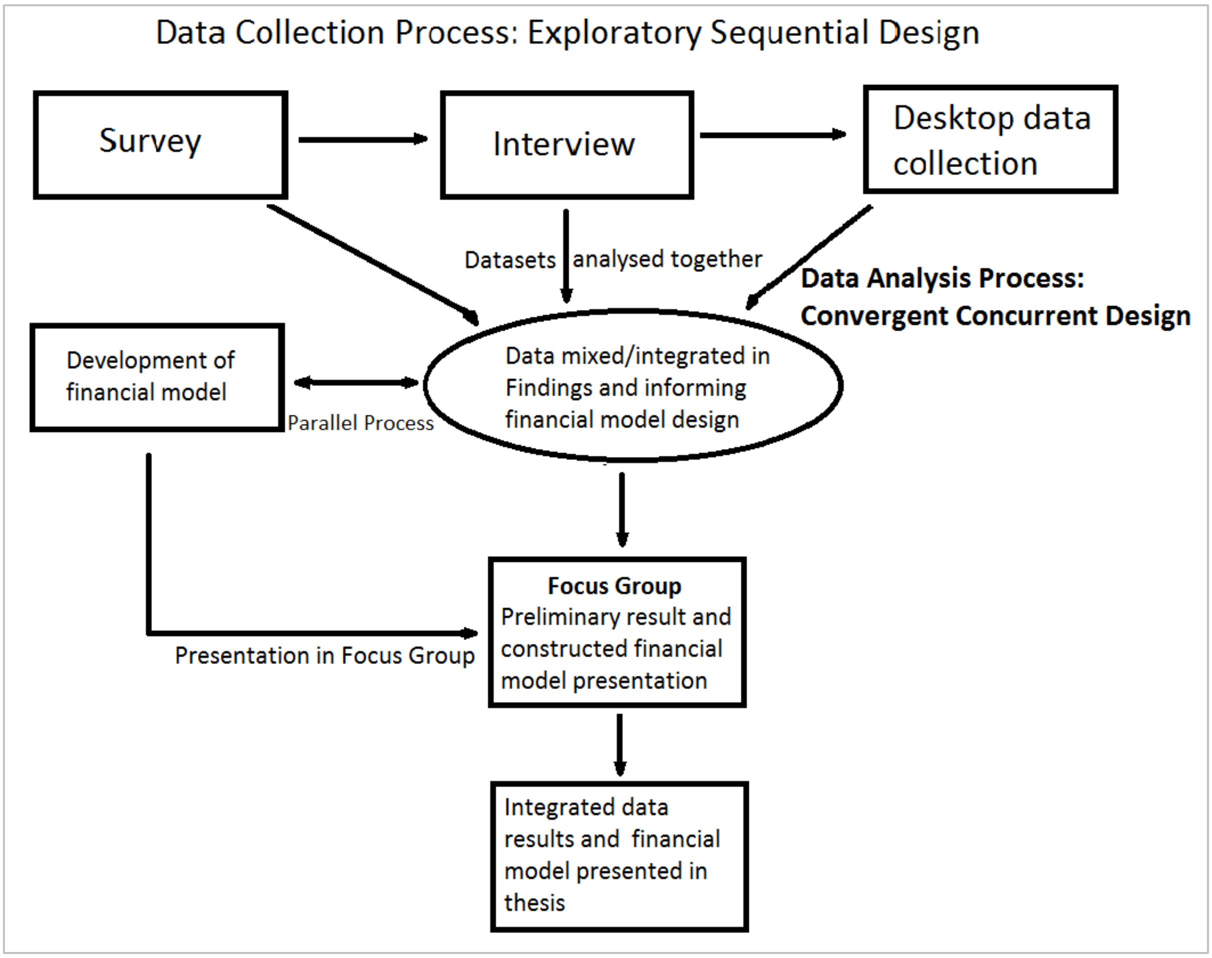

Figure 3-1 Data Collection and Analysis Processes Design

3.1.2 Data collection processes

3.1.2.1 Survey questionnaire

The survey questionnaire comprised of three components: two questionnaires and an Excel spreadsheet. The questionnaires were prepared for two different participants within the council, the environment manager or officer and the finance manager or equivalent. Both persons were to have knowledge of the decision-making processes for the implementation of climate change mitigation / alternative energy projects. The two respondents were identified to enable a comparison in response based on their technological, policy and financial background being located within different departments in the respective organisations. The purpose of the Excel spreadsheet was to obtain factual data on completed and planned energy projects undertaken by the respective councils. Another table was used to obtain data on energy consumption cost and kWh from their target baseline year onward. Refer to Appendix A for the survey questionnaire.

3.1.2.2 Semi-structured interview

Data from the survey were analysed to inform part of the questions for interview with each respective council. This tailored questions unique to an individual council to clarify any data provided in the questionnaires that was unclear, or to discuss any emerging theme from the survey, or solicit more internal supporting documents. Other questions are the same for all councils, and consist of questions for discussion such as who is driving the mitigation policy, motivation, tracking and reporting process, financial evaluation process, specific challenges and barriers and the underlying cause. The interview questions were designed to extract mostly qualitative information that could provide more in-depth knowledge to enhance answers to the four research questions.

3.1.2.3 Desk-top research and data collection

The profile of each council is different despite their location in Sydney. Factors such as the geographic location and its size, population and demography, household income level and the business mix, as well as the political makeup of the councillors, shape their financial resources and capacity. The political makeup of the leader, financial resources and capacity in turn motivate each council's mitigation priority and ability in carrying out effective actions. To gather information on councils, an extensive study was conducted on all participating councils' websites to collect data from their financial statements, annual delivery reports, end-of term reports, State of Environment Report and various environmental sustainability progress reports, community strategic plan and master plans etc. In addition, the secondary and comparative data were collected from the ABS website, Treasury Corporation's LG sustainability study report and the Office of Local Government's publication "Comparative Information on NSW Local Government" (Treasury Corporation, 2013; NSW Government, 2014)

3.1.3 Data analysis processes

The data analysis process was conducted by importing data from the survey questionnaire into Excel spreadsheet in a tabular format for analysis and comparison of the five councils. The interview recordings were transcribed and imported as text into table for grouping and analysis to identify any emerging theme. In order to minimise the subjectivity when assessing the qualitative and semi-qualitative data, an evaluation scale of 1 to 5 (1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high) was used in assigning the relative score among the five councils. In some cases, multiple indicators were scaled and aggregated to arrive at a single more objective score (Refer to Section 4.2.3 for example). More importantly, the Focus Group was designed as the final step for the participants to provide feedback on the validity of the preliminary findings and the usability of the constructed financial evaluation model.

3.2 Construction of financial evaluation model

The literature review identified a gap in the knowledge, practice and tools to assist in the evaluation of small alternative energy projects, which is common in most councils. Staffing and resources of councils in NSW are generally smaller than the larger councils in Victoria and Queensland. As the focus of this thesis was on councils in NSW and specifically within metropolitan Sydney, the development of a financial evaluation model for this sector was identified as an aim for this thesis. The precondition of the financial model is that it had to be relatively simple and easy to use by both financial and environmental staff within councils. By showing the calculation formula in a spreadsheet connecting to the complex mathematic formula, it is easily understood by a range of professionals (including environmental and finance staff) and able to be adapted and modified for the needs of individual council.

The concept in the design of the model is based on the Cost of Renewable Energy Spreadsheet Tool (CREST) available from the National Renewable Energy Laboratory (NREL) (Gifford & Grace, 2013). CREST is a financial cash-flow model for assessing utility-scale of renewable energy projects, mainly PV and solar thermal. The concept of the investment capital cost, cash-flow, present value, discount rate and evaluation measuring criteria is based on *A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies* from the NREL (Short et al., 1995).

3.2.1 Present value and discount rate

The investment of the rooftop solar PV systems requires a large initial sum of capital to be sunk and locked in for long period of time, whereas the cost-savings from locally generated PV electricity offsetting the grid electricity charges are over the total long lifespan of the equipment. These costs and benefits need to be brought to the present values by a selected discount rate for a fair comparison (Short et al., 1995). Based on a recommendation from the NSW Treasury (2007), a real discount rate of 7% is adopted for the model.

3.2.2 Financial evaluation criteria

A financial evaluation model requires a robust comparative measure of all the monetary costs and benefits of an investment to inform sound decision-making. The model has adopted from Short et al. (1995) such evaluation measuring criteria as NPV, DPP, IRR and LCOE, together with the following application and calculation formulae.

3.2.2.1 Net Present Value (NPV)

NPV is one of the most common financial evaluation criteria suitable for analysing the viability of an investment (Short et al., 1995). It can also recognise an optimum size of investment alternatives for more favourable outcomes. A simple rule of using NPV is to undertake projects with positive NPV and abandon projects with negative NPV (Ross, 1995). These decision criteria are based on the theory that a positive NPV indicates an investment project is considered viable, as the total present value of its benefits exceeds its costs (NSW Treasury, 2007). From an institutional perspective, this also implies that positive NPV projects will increase the corporate resources in the future, whereas negative NPV projects will have the opposite effect to the institute (Stulz, 1990). Assessing investment value in capital budget constraint conditions and making sound decisions would need to consider the NPV value with alternative investment options in terms of timing in either now or in the future, as every investment competes with its own delayed future time value (Ross, 1995).

NPV is the sum of the discounted project benefits minus the sum of the discounted project costs over the entire time horizon of n=0, 1, 2, … , N years. The calculation formula of the NPV can be expressed as follows (Short et al., 1995):

$$NPV = \sum_{n=0}^{N} \frac{B_{n-}C_n}{(1+d)^n}$$

Where:

NPV = net present value

B_n = project benefits in year n expressed in constant dollars

C_n = project costs in year n expressed in constant dollars

N = number of years that costs and/or benefits are produced

d = real discount rate

3.2.2.2 Discounted Payback Period (DPP)

DPP is the number of years required to recover the total project costs from the investment, while accounting for the time value of the capital involved (Short et al., 1995). DPP is an easy and quick evaluation measure suitable especially when risk and uncertainty considerations are crucial to the decision making, as it allows for a quick assessment of the duration an invested capital is at risk. If the DPP exceeds the total lifecycle of the plant, the project would have a negative NPV, which implies the investment will not be fully paid back. In effect, DPP is a modification of the NPV method while ignoring any returns after the capital payback have been achieved (Lefley, 1996). Therefore, it is not the right tool to measure the profitability and provide the investment ranking of the projects. However, with a properly set hurdle payback period, DPP can be used as a supplementary evaluation criterion in supporting more sophisticated methods such as IRR and NPV to achieve effective investment decision-making (Lefley, 1996).

The DPP can be expressed as the year in which (Short et al., 1995):

DPP = K = the year when:

$$C + \sum_{n=1}^{K} \frac{F_n}{(1+d)^n} \leq \sum_{n=1}^{K} \frac{B_n}{(1+d)^n}$$

Where:

DPP = minimum number of years required when the discounted sum of all costs is equal to or less than the discounted sum of annual cost-saving benefits

C = Initial capital cost

F_n = Fixed operations and maintenance cost in the year n

B_n = Annual cost-saving benefits from electricity offset

d = Real discount rate

K = The year in which the above condition is true

3.2.2.3 Internal Rate of Return

IRR is the discount rate at which the net present value of a project is equal to zero, which indicates the discounted benefits equal discounted costs (Short et al., 1995). In effect, the IRR formula implicitly assumes the reinvestment of returns at a rate equal to the IRR, which is not possible in the practical world and can lead to a major distortion of the assessment (Akalu, 2001; Kelleher & MacCormack, 2004).

IRR is commonly used for a single project analysis that produces accept or reject decisions based on comparison with a minimum acceptable rate of return, which is a hurdle rate that could be set to the cost of capital (Short et al., 1995). However, IRR is not recommended when selecting among mutually exclusive alternatives, as the values of differing investment sizes are ignored (Short et al., 1995). At the same time, both Akalu (2001) and Magni (2010) have pointed out a few shortcomings of IRR as an assessment tool:

- A real value of IRR may not exist, so that the comparison with the cost of capital is not possible.
- Multiple IRRs may arise when non-conventional patterns of project cash flow happen which makes comparison problematic.
- The result of IRR may not be compatible with the NPV, for example, a short-lived small project with a high IRR would be more favoured than a long-lived, capital-intensive project, which tends to be put down the list even if their net present value is substantial.

Despite these shortcomings, IRR remains popular as managers, analysts, and practitioners often find it useful especially when being explicitly required to supply a performance measure in terms of rates rather than present values.

In algebraic terms the IRR is the value of r when the following equation is solved (Short et al., 1995):

$$NPV = \sum_{n=0}^{N} \frac{B_{n-}C_n}{(1+r)^n} = 0$$

Where:

NPV = net present value

B_n = project benefits in year n

C_n = project costs in year n

N = total lifecycle of project that costs and benefits are produced

r = IRR or (real discount rate)

3.3.1.1 Levelised Costs of Electricity (LCOE)

LCOE is the discounted Total Life-Cycle Costs (TLCC) distributed to every unit of electricity produced by the generation system over its total productive lifecycle (Short et al., 1995). It can be interpreted as the price at which electricity must be generated from a specific plant to break even with the costs incurred over the life of the plant (BREE, 2013). The levelised cost approach in analysing the generation cost is a widely used tool for comparing the costs of different power generation technologies, particularly in the modelling and policy discussions arenas. LCOE provides a transparent consensus measure of generating costs; hence, it is often used as a key comparative cost indicator across renewable energy technologies as well as against the conventional energy technologies for their market competitiveness and readiness (BREE, 2013). For example, LCOE is used by IEA-OECD (2010) to study costs of various electricity generation technologies in the participating countries to provide insights into their relative costs; it is also instrumental in comparing unit cost of 40 electricity generation technologies under Australian conditions to see their market competitiveness (BREE, 2012), as well as mapping the solar grid-parity in Australia (Chen & Franklin, 2011).

The following are some applications of LCOE for various purposes (IEA-OECD, 2010):

- Identifying the least-cost option among alternative generation investments.
- Evaluating the impact of market changes on generation costs.
- Assessing the cost structure of various generation options.
- Assessing the impacts of changes in key assumptions, including key policy parameters such as carbon prices, on unit costs.

The average unit cost of generated electricity over the entire operating life of the solar PV system is equal to the present value of the sum of discounted costs divided by total electricity production adjusted for its economic time value (IEA-OECD, 2010). The key elements included in the calculation of the LCOE for the model are the capital cost, fixed O&M cost, discount rate, and the lifecycle of the plant. The LCOE is expressed in real Australian dollars per Kilowatt hour of electricity generation ($/kWh). The capital and fixed O&M costs are based on the price data provided in the BREE (2013) report. The calculation formula for the LCOE for a solar PV generation facility and its component parts are defined as follows (Short et al., 1995; BREE, 2012):

$$LCOE = \frac{C + \sum_{n=1}^{N} \frac{F_n}{(1+d)^n}}{\sum_{n=1}^{N} \frac{E_0 * (1-S)^n}{(1+d)^n}}$$

Where:

LCOE = Levelised cost of electricity generated over lifetime ($/kWh)

C = Initial capital cost

F_n = Fixed operations and maintenance cost in the year n

E_0 = Initial electricity generation in base year

d = Real discount rate

S = Solar PV generation degradation rate

N = Total lifecycle in years of the plant

4 Results and findings

The results and findings presented in this section are specifically addressing the following four research questions posed for the study:

1. What emission mitigation targets were set, and how were they accounted for and monitored in tracking progress?
2. What is the priority of the climate change mitigation policy in the councils' operation and what is the impact of the financial sustainability on the decision-making regarding the target and priority?
3. What are the challenges and barriers in mitigating the local emissions:
    c. From an institutional capacity perspective
    d. From National Electricity Market (NEM) regulation perspective?
4. What financial evaluation processes were adopted in ensuring the economic viability of the alternative energy projects and if the accounting of the projects' performance was tracked and aggregated?

4.1 Emission targets and progresses tracking

Q.1 What emission mitigation targets were set, and how were they accounted for and monitored in tracking progress?

4.1.1 Key findings

1. Emission targets are consistent with the national Renewable Energy Target (RET) set in the *Clean Energy Act 2011* (Cth) and in line with the NSW State's support to the national RET.
2. Baseline year varies across each council.
3. All councils use specific data management software to track and report their emission progress.
4. There is considerable variability in the data collected to date that limits comparative analysis among the councils participating in the study.

4.1.2 Findings analysis

4.1.2.1 Emission targets

Two main points can be identified in the response (see Table 4-1).

There is a common theme of a 20% reduction in greenhouse gas emissions by 2020. This reduction target may reflect the general support by the local government sector to the national RET set in the *Clean Energy Act 2011 (Cth)* and an alignment to the NSW State Renewable Energy Action Plan (NSW Government, 2013a). The NSW State Plan similarly mirrors the national target of 20% renewable energy by 2020 with emphasis on achieving it at least cost and capturing maximum benefits from the federal funding (NSW Government, 2013a).

There are two exceptions, from the councils of North Sydney and City of Sydney (Table 4-1). North Sydney Council has a target of a 50% emissions reduction from 1996 levels by 2020. The City of Sydney Council has three targets: 26% emissions reduction from 2006 levels and 5% of renewable electricity by 2016; 70% emissions reduction from 2006 levels and 30% renewable electricity by 2030; and 100% local energy generation and no reliance on coal-fired electricity by 2030. Their second and third targets are positioned around long-term goals that apply to both the council's own operation and the emission profile of their whole local government area (LGA). The first target is an interim measure for 2016. This can be viewed as a near-term goal to assess the performance of the council's own operations against their 2030 goals. The City of Sydney is the only council that had set a long-term specific target for their own operation as well as their whole LGA, which is linked to their 'Decentralised Energy Master plan – Tri-generation 2010–2030'.[9]

The base-year on which the 20% reduction is taken varies across the councils from 1996 to 2012. This variability in base line makes it difficult to compare emission profiles and actions between councils. For those councils that have a later benchmark year, such as Willoughby Council, recent energy mitigation initiatives prior to this date would not be incorporated into their analysis. Responses by council officers as to the selection of their base-year has been largely determined by their data collection and confidence in the data, particularly in the earlier years, such as that captured under the ICLEI's CCP program. All councils reported that

[9]This plan is currently (as at September 2014) on hold based on the recent report on the economic viability of the project. Link to the Trigeneration Master Plan document: http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0004/143365/130617_EC_ITEM02_ATTACHMENTD.PDF.

the use of recent energy management software has improved their data collection with some nominating new base year (Table 4-2).

Table 4-1 Council emission mitigation targets

Bankstown	City of Sydney	Ku-ring-gai	North Sydney	Willoughby
20% emission reduction of 2009 level by 2020	26% emission reduction and 5% renewables electricity of 2006 level by 2016 70% emission reduction and 30% renewable electricity of 2006 emissions by 2030 100% local energy generation and no reliance on coal-fired electricity by 2030	20% emission reduction from 2000 electricity (ex street lighting) and fuel use by 2020 and 90% by 2050	50% emission reduction from 1996 levels by 2020	20% renewable electricity for buildings based on 2012 level by 2020

All five councils were members of the CCP program (1997–2009). Each achieved the five milestones[10] under this program. Council officers acknowledged that the CCP program assisted their organisation in taking stock of their emission inventories and setting an initial target and baseline, which for some councils has since been modified. The cessation of the program in 2009 and its support, coupled with staff changes in the intervening period, had left gaps in knowledge, tracking and reporting of the progress against the baseline. This is especially so for Bankstown, Ku-ring-gai and Willoughby councils, which had prompted their recent decisions to acquire dedicated data management software.

4.1.2.2 Progress Tracking and Reporting

The anomaly and variability in baseline leads to the question on accounting, monitoring, tracking and reporting of their progress against the targets. The responses to these questions are summarised in Table 4-2.

[10] The five milestones: (1) Conduct an inventory; (2) Establish a goal; (3) Develop the Local Action Plan; (4) Implement policies, plans and measures; (5) Monitor and verify results.

The progress data for Bankstown, Ku-ring-gai and Willoughby were provided with various degrees of effort to them, which reflects the lack of integrated tracking and reporting data available for effective access. Their recent procurement of a dedicated software system and the process to transfer and integrate data from their existing platform will likely help improve the reporting of emissions and performance of their mitigation programs. North Sydney has maintained continual tracking and reporting of its annual emissions from 1996 to the present, relying on the Planet Footprint (Table 4-2). Willoughby is reporting environmental levy funded activities quarterly through 'e-restore',[11] which does not report with clear reference to the baseline. Therefore, it is difficult to measure their performance against baseline, which was not provided with confidence of accuracy due to the current transitioning between the two data platforms.

The City of Sydney has adopted two software tools to track their energy use and emission profile. One tool is mainly used in monitoring and reporting on Council's own energy and emissions progress. It is a Utilities Information Monitoring System that can access real-time energy usage through direct interface with appropriate energy suppliers such as Ausgrid, and allow effective monitoring and reporting of energy consumption via smart meters. The other tool is used in collecting and reporting on LGA-wide aggregated energy and emissions. The baseline tracking for both LGA and Sydney's own operation energy and emissions are reported twice yearly in their Green Reports[12], and once a year in the annual State of Environment Report.

[11] e.restore is a branded name for the Willoughby Council's environmental levy to fund their environmental improvement programs, which are reported quarterly under the same name. http://www.willoughby.nsw.gov.au/DownloadDocument.ashx?DocumentID=10469

[12] The Green Report can be downloaded from the link: http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0019/212761/Report-Green-Report-January-to-June-2014-Final.pdf

Table 4-2 Tracking and reporting of progress against the baseline

	Bankstown	City of Sydney	Ku-ring-gai	North Sydney	Willoughby
Total baseline (tonnes CO2-e)	16,972 (2009) 15,208 (2013)	52,972 (2006) 43,945 (2013 offset)	4,484 (2000) 4657 (2011/12)	8,465 (1996) 6,571 (2012/13)	9,121MWh (2012) 8,942MWh (2013)#
Emission reduced (tonnes CO2-e)	1,764 (10%)	9,027 (17%)	173 (4%) increase *	1,894 (22%)	179MWh (2%)
Green Power / Offsets	No	Offset - carbon neutral in 2011	No	Green Power	Green Power
Total Cost of Electricity	**$6,830.000 (2014)**	**$5,992,971 (2014)**	**$1,621,495 (2013)**	**$1,171,700 (2013)**	**$1,438,788 (2013)**
Cost of Street Lighting and (% to total)	**$4,030,000 (59%)**	**$1,919,334 (32%)**	**$756,000 (47%)**	**35% (2013/14) ****	**$358,931 (25%)**
Tracking tools	Envisi (GreenTrack)	STVeV and CCAP	Envisi	Planet Footprint	Envisi

 # Willoughby's baseline figures include street lighting, which should be excluded. However, due to technical problem, at the time, a more reliable figure cannot be provided. Therefore the emission reduction figure is also not accurate.

***Ku-ring-gai increase emission by 4% instead of reduction, hence is highlighted in red.**

****Percentage for North Sydney's street lighting is in kWh as to total electricity kWh used. The rest are all in terms of cost in $ value.**

4.1.2.3 The challenge of setting targets and tracking progress

Setting an emission reduction target, councils usually follow the Commonwealth reporting on greenhouse emissions guideline, which requires differentiating between emission sources for comparison purposes. These are divided into three categories: 'Scope 1',[13] 'Scope 2'[14] and 'Scope 3'[15] emissions (Commonwealth of Australia, 2012). During the mid to late 1990s, many councils were keen to set ambitious greenhouse gas reduction targets. For example, North Sydney's target of 50% reduction from 1996 by 2020, Willoughby's earlier target in 2000 to reduce 50% from its 1999 levels by 2010[16] and City of Sydney's target of 100% reduction and offset of emissions from Council operations and services by 2008. For many councils, such as North Sydney, Sydney and Willoughby, their initial strategy to achieve their targets relied on the substitution of coal-based electricity to GreenPower[17] and carbon offsets, such as forestry

[13] Scope 1: Direct (or point-source) emission factors i.e. gas, fleet fuel and so on.
[14] Scope 2: Indirect emission factors i.e. mains electricity emissions.
[15] Scope 3: Various emission factors from flights, taxis, contractors' fuel, and events.
[16] Carbon Reduction Strategy 2008:
http://www.willoughby.nsw.gov.au/DownloadDocument.ashx?DocumentID=2665
[17] A special 777 State Supply Contract organised by the NSW State government.

plantings, were also used to achieve emission reduction targets. Such strategies reflected the emerging market opportunities in these two areas that have since lessened in strength. More recently, many councils that have adopted a similar approach have progressively phased out the purchase of externally generated GreenPower in favour of investing in their own energy generation projects, such as the installation of photovoltaic systems.

A good example was the decision of the Sydney Council to cease the purchase of GreenPower since 2008 and dedicate the yearly saving of $2 million to their ‘Precinct Scale Solar PV Program’. The council still maintains its carbon-neutral status by a more cost-effective certified National Carbon Offset Standard[18]. North Sydney Council has achieved significant progress through GreenPower and reduced to a level in maintaining their current reported reduction achievement. Willoughby Council had adopted both offset and GP to achieve their target by 2008, but later dropped the offset and significantly cut down on GreenPower.

Each respondent reported that tracking and reporting of energy use demanded significant institutional resources. This included the capital and leasing costs associated with the software tools and dedicated staff time to review, analyse and report the data and associated activities with ongoing training on the software. At present, there is no national standardised reporting format for local government. This limits the capacity to compare and analyse emission data that may iteratively inform future strategies, projects and refining targets. A similar observation was made by Storey et al. (2012) in her analysis of climate change mitigation actions by local government.

4.2 Priority of climate change mitigation and institutional capacity

Q.2 What is the priority of the climate change mitigation policy in the council’s operation and what is the impact of the financial sustainability on the decision making regarding the target and priority?

[18] The aim of the certified carbon offsets is to ensure the offset projects in the developing world are genuine and not being double counted. Emission Inventory and Offset reporting is available at http://www.cityofsydney.nsw.gov.au/vision/sustainable-sydney-2030/strategic-directions/a-leading-environmental-performer/carbon-reduction/carbon-neutral

4.2.1 Key findings

1. The priority of climate change mitigation policy by councils reflects their capacity-to-spend (financial resource) and willingness-to-spend (political and executive leadership commitment), and would seem to be informed by the effectiveness of tracking and reporting (facilitated by staff technical skills and enabling software tools).
2. Capacity-to-spend is influenced by factors such as its rate base (population size, the business/residential property rate mix), household income level, and the council's income generating asset base.
3. Willingness-to-spend is shaped by the political makeup of the leaders (councillors), and the abundance of low-hanging fruit.[19]
4. The mitigation target and its priority in councils are a result of the dynamic interaction between their capacity-to-spend and willingness-to-spend.

4.2.2 Findings analysis

4.2.2.1 Financial sustainability underpinned council's capacity-to-spend

To achieve an emission reduction target, the focus of a council most often turns on the direct costs associated with electricity, gas and fuel. Investment in one or more of these areas requires motivation and 'financial capacity' that must be weighed up with all other policy commitments and potential projects. The pressure on financial resources and expectations on service delivery faced by local government is an ongoing issue and affects NSW councils particularly due to their limited capacity to raise rate income (IPART 2009). For a council to invest on energy projects depends largely on its long-term financial sustainability, considering asset liabilities (such as road and property maintenance) and income sources such as rates, grants and income-generating assets (IPART, 2009).

To assess the financial sustainability of the councils, their annual financial statements were examined for their operating results. All councils reported a surplus in 2012/13 (Table 4-3). However, there is a significant range in the operating surplus, with Bankstown Council reporting $0.608 million to City of Sydney reporting $113.85 million. In part this can be reflected by the variability in rate income and proportion of business and residential properties (shown in Table 4-4) as the business rates are typically higher than residential as

[19] Councils considered energy efficiency retrofitted, solar PV on the office building blocks that use energy during daytime to be a low-hanging fruit, as the projects usually have favourable payback to be easily justified.

related to land value (Clark, 2012). Investigating the financial information in both Tables 4-3 and 4-4, it is clear that City of Sydney is significantly different to the other councils, in that its 'Business/Residential' rate income percentage of 368% and rental income from its building assets are much higher than in the other councils. With such financial strength, any application from City of Sydney for special rate variation to fund specific projects or activities would not be supported by IPART for approval, whereas the environmental levy application for North Sydney and Willoughby were granted permanently and Ku-ring-gai's was from 2005 until 2019.

Table 4-3 shows that Bankstown is without the environmental levy for a very different reason than the City of Sydney. Given the political makeup and demographics of the council, Bankstown had confirmed in the interview that they need to keep rates at a reasonable level for their community, which may affect their capacity-to-spend.

Table 4-3 Council financial operating results 2012/13 and FSR

	Bankstown	City of Sydney	Ku-ring-gai	North Sydney	Willoughby
Total Income ($m)	**147.51**	**599.25**	**111.55**	**104.75**	**110.45**
Total Grant Capital and Operation ($m)	**19.90**	**109.37**	**17.58**	**7.28**	**17.60**
Grant / Income (%)	**13.5**	**18.25**	**15.76**	**6.95**	**15.9**
Environmental Levy ($m)	**0**	**0**	**2.49**	**1.82**	**5.08**
Operating surplus or (deficit) ($m)	**0.608**	**113.85**	**15.81**	**18.42**	**15.07**
Debts ($m)	**7.47**	**0**	**31.68**	**0**	**51.85**
Net Assets ($m)	**2100**	**7280**	**984**	**729**	**2770**
Population (2013 ABS 3218.0)	196,974	191,918	119,027	69,248	73,155
Average household taxable incomes (NSW OLG 2012/13)	$39,083	$56,470	$81,612	$84,686	$77,896
Fiscal Star FSR (2009)	Sustainable	Sustainable	Unsustainable	Sustainable	Vulnerable
NSW Treasury Corporation FSR / Outlook (2012)	Moderate / Negative	Strong / Positive	Sound / Neutral	Moderate / Neutral	Moderate / Neutral

Table 4-4 Comparison of councils' own revenue base (2012/13)

	Bankstown	City of Sydney	Ku-ring-Gai	North Sydney	Willoughby
Residential Rate Income ($m)	53.73	51.28	23.96	17.01	22.30
Business Rate Income ($m)	25.16	188.84	3.70	11.10	17.43
Business / Residential %	46%	368%	15%	65%	78%
Rental income from asset ($m)	2.79	54.87	4.30	5.09	8.30

The financial sustainability rating (FSR) from Fiscal Star (2009) and the FSR/Outlook rating from the Treasury Corporation (2013), as listed in Table 4-3, provide a good insight into the councils' financial sustainability. Together, the two assessment studies cover the period from 2005 to 2012, rating to long-term financial sustainability and outlook for the near-term future of the five councils. As shown in Table 4-3, their ratings confirmed the above analysis on the exceptional financial strength of the Sydney Council, the moderate financial strength of other North Shore councils, and the slight concern on Bankstown's outlook.

4.2.2.2 Willingness-to-spend–political and executive leadership commitment

Having a capacity-to-spend will not necessarily translate into a prioritised spending in the mitigation projects, as councils have many community and environmental services obligations competing for limited financial resources. There are many elements affecting councils' willingness-to-spend in mitigation actions: the political makeup of the leaders, for example, the majority of councillors in the City of Sydney are in favour of a strong mitigation policy; if there is 'low-hanging fruit' in councils' operations, it would be easier to gain political support from the councillors and the top executive due to the favourable financial payback periods as an impressive return to the councils' achievement against policy commitments. For example, North Sydney had steady support from their Lord Mayor, but was limited by its lack of property with favourable daytime electricity consumption patterns to justify a cost effective PV installation. Willoughby with a similar building profile, invested heavily in their Westfield solar farm projects, which could be interpreted as a higher willingness-to-spend in the council without taking into account the actual investment performance.

Willingness-to-spend is also reflected by the actions prioritised in the council's community strategic plan (NSW Government, 2013c). This document is designed to reflect the main priorities and aspirations of the local community, which, in turn, are supported by a resourcing strategy to fund a four-year and annual program of works and services. While the community strategic plan (CSP) is designed to be developed by the community, it is the elected councillors who approve the plan and its associated budget, thus the council's willingness-to-spend. To assess councils' willingness-to-spend dynamic on their mitigation policies, findings from analysis of the community strategic plans in relation to energy mitigation projects, survey data on the past mitigation projects and interview of each council are presented below.

Bankstown City Council

The Bankstown Community Plan 2023 outlines 27 Term Achievement (TA) statements that describe what Council aims to deliver over the four-year council term. In that plan, TA 10 is the only statement that refers to 'Council will better utilise our energy and water resources'. Therefore, there is very little emphasis on mitigation plans in their CSP. The interview with the council confirmed that there is no specific climate change champion within the elected councillors. Survey data show that the 143kW solar PV installations were largely supported by federal and state government grants and rebates. Due to their low value as an individual project, they were not assessed for their financial viability, whereas the council's tri-generation project benefited from a $2 million grant linked to the redevelopment of their Civic Centre and precinct that had been commissioned to professional consultants for economic evaluation. Overall, the Council is able to remain on course with the baseline and managed to achieve a 10% reduction.

City of Sydney Council

The Sustainable Sydney 2030 community strategic plan of the City of Sydney has set ten 2030 targets and ten Strategic Directions that provide a framework for actions. In that plan, the City of Sydney adopts ambitious emissions reduction targets by way of clearly laid out actions on the development and implementation of master plans in energy efficiency, renewable energy and decentralised energy. The interview with the council's manager confirmed that their Lord Mayor has championed action of climate change since 2004 and Sustainable Sydney 2030 is a reflection of that strong support. The survey stated that a vast majority of current councillors support environmental improvements. A review of their organisational structure revealed that the Sustainability Department occupies a significantly high directorate hierarchical level under the Chief Operations Office and Allan Jones as CDO for Energy and Climate Change right under the CEO of Sydney Council.

Survey data indicate that each specific unit is responsible for a target. The Sustainability Strategy Unit has responsibility for tracking and ensuring that each unit is aware of the targets and is including sufficient actions within its work plans. The main sources for energy and emissions are properties, street lighting, and to a far lesser extent, fleet. Since 2012, a two-year project at a cost of $4.3 million to install 1.25MWp of solar PV on 30 of the City's buildings has been under way. This is in addition to the solar PV installations already in place on rooftops of 18 other City's properties. These projects are funded with the $2 million annual saving from the cessation of the GreenPower purchase. At the same time, the City is rolling out a $7 million[20] three-year project to replace its own 6,448 conventional street and park lighting with new, energy-efficient light emitting diodes (LED), with around 42% completion at the last quarterly report. Since March 2012, the council reports a saving of almost $370,000 and a reduction of more than 34% in energy use.

Ku-ring-gai Council

The Community Strategic Plan 2030 of Ku-ring-gai Council has set mid- to long-term targets and objectives on its carbon footprint reduction by way of more sustainable fleet management, alternative energy sources usage and reduction in both building and street lighting energy consumption. There is no clear plan or action laid out in the plan. The interview revealed that there is no champion from the elected councillors or senior management supporting climate change mitigation action. Survey data show the installation of 52kW solar PV in total, together with a range of energy efficiency projects which are quantified to have saved 846,886kWh of energy annually. Since 2013, Ku-ring-gai has commissioned a consultant to audit and update the GHG emission inventory in order to review and develop new strategy, since the total emissions are increasing even though there was a 17% reduction in fleet emission. The newly revised target is to exclude the street lighting from the original target while maintaining the 2000 baseline year. As the street lighting is categorised as Scope 3, the

[20] Fully self-funded, as Sydney owns all these lights.

council has no direct control over its emission. However, it still shows an overall increase of 4% against the same base year. The survey disclosed that, as part of their new initiative to improve emission reduction, the Environment team is seeking to establish a cumulative emissions budget to be apportioned to departments and/or assets. This will create the need for departments to manage their emissions as part of their operational mandate.

North Sydney Council

The 2020 Vision community strategic plan of North Sydney has set a broad scope of five interlinked and interdependent directions to guide and inform its decision making and planning until 2020. In it, the council stresses its role as a key driver of the 2020 Vision, while its implementation would be the responsibility of all community stakeholders, with little focus on mitigation policy. The interview confirmed that there was strong support from the former Lord Mayor until 2012. Since her retirement, the new Lord Mayor has not carried on the support with similar enthusiasm. Apart from a grant co-funded energy efficiency and cogeneration project for an Olympic pool and a small solar hot water system, there is no solar PV project reported in the survey. Further study of their report found that a large part of its reported emission reductions comes from the 50% purchase of GreenPower at its top energy consumption sites, which carries an ongoing cost. The interview uncovered that the council had already implemented early emission reductions by EE retrofitting, which is cost effective with acceptable payback periods. As mentioned above, they are limited by their properties profile with an unfavourable electricity consumption profile, which has made the PV project financially unattractive.

Willoughby City Council

The community strategic plan 2010–2025 of Willoughby City Council has set six key strategic directions, one of which responds to climate change by committing the council to achieve its emissions reduction target through strategic actions. These actions include the preparation and implementation of a sustainability action plan; investing in alternative energy to reduce reliance on grid-supplied power; and adopting sustainable asset management systems in relation to building and fleet management.

An interview with Willoughby Council found that there is a Greens Party councillor who favours a climate change mitigation policy, but without support from others. Therefore, there is no strong driver at the councillor level. However, there are a couple of supportive middle management people in the council. In its earlier carbon reduction strategy in 2008, Willoughby had set an ambitious target of 50% emissions reduction, based on the 1999 level, by 2010, which they had achieved by both offsetting and GreenPower (discussed in Q.1). In the intervening years, the Council had installed a total of 234kW solar PV and 160kW of tri-generation capacity. The survey input with raw data showed numerous tree offset and EE retrofitting projects, but it was impossible to quantify these. The resetting of their target to 20% electricity from buildings at 2012 level by 2020 is a result of a data collection gap that makes tracking and reporting difficult. In effect, it has excluded the Scope 3 street lighting from the target without being specific. The challenge would be having less time to achieve targets due to the foregone of previous effort.

4.2.2.3 Effective tracking and reporting as a result of staff skill capacity

The findings for Q.1 show that the challenges in tracking and reporting of progress against the baseline demand significant internal resources, such as an effective tracking and reporting capability, linked to specific skills of technical staff and supported by enabling software systems. It is also an aggregated result of collaborative efforts among many internal departments and responsible personnel in collecting data. Therefore, a comprehensive and purposeful tracking and reporting capability offers an insightful indication of the staff capacity, which also reflects the working of the capacity-to-spend and willingness-to-spend condition of a council. Refer to Q.1 for more details on tracking and reporting findings.

4.2.3 Climate change mitigation policy priority in councils’ operation

The findings and analysis above and in Q.1 have uncovered a dynamic relationship between councils’ institutional capacity and consequently their priority of climate change mitigation policy in their operations. It is not a straightforward, simple relationship, since there are many factors and conditions, such as council’s leadership dynamic, energy consumption and asset base profile, that are interacting and shaping the course of its capacity-to-spend, willingness-to-spend and staff-skill-capacity. In addition to this complexity is the challenge in reporting quantitative data combined with qualitative and subjective analysis on the profile of a specific council.

In order to minimise the subjectivity when assessing the priority of climate change mitigation policy in councils' operation, an evaluation scale of 1 to 5 (1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high) was used in scoring the three institutional capacity elements listed in Table 4-5 (highlighted in green). The score of each of these three elements is derived from averaging similar scale scoring from their effecting factors listed above each green-row in Table 4-5. For example, the scaling analysis of councils' capacity-to-spend takes into account their current operating result, revenue-raising capability, asset base, debt level and the FSR rating from both Fiscal Star and Treasury Corporation. The factors affecting the score of willingness-to-spend are leadership support and commitment, highlights in the Community Strategic Plan, availability of low-hanging fruit projects on council properties, completed EE and PV projects, and progress achieved. Lastly, the tracking and reporting clarity, well-integrated data for effective access and enabling data management tools used are factors shaping the score of the effective-tracking-reporting element. Each of the factors has been weighted equally to avoid getting too complicated, and the effective-tracking-reporting are based on the current status even though the three councils had acquired the software tool that may help in future improvement.

The score ratings are indicative of the relative priority of climate change mitigation policy in the operation of each council. Table 4-5 shows that the climate change mitigation policy is relatively very high in priority for the City of Sydney's operation, which reflects a confluence of these elements of their institutional capacity that has enabled the potential of setting and achieving their ambitious target. The results also demonstrate that the decision-making on the mitigation target and priority in a council is not subject to only a single factor.

Table 4-5 Assessing and comparing priority of climate change mitigation policy in councils

	Bankstown	City of Sydney	Ku-ring-Gai	North Sydney	Willoughby
Operating result	**3**	**5**	**4**	**4**	**4**
Revenue raising capacity	**2**	**5**	**3**	**4**	**4**
Asset base	**4**	**5**	**3**	**3**	**4**
Debt level	**3**	**5**	**2**	**5**	**2**
Treasury Corp & Fiscal Star FSR	**3**	**5**	**3**	**4**	**3**
Capacity-to-spend	3	5	3	4	3.4
Leadership support	3	5	3	3	3
Mitigation highlight in CSP	2	5	2	2	4
Low-hanging fruit	3	5	2	2	3
Completed energy projects	3	5	2	2	4
Progress reported	4	5	2	4	3
Willingness-to-spend	3	5	2.2	2.6	3.4
Enabling software tool	4	5	4	4	4
Integrated & easy access of data	2	5	2	3	2
Tracking & reporting clarity	2	5	2	3	2
Effective tracking & reporting	2.7	5	2.7	3.3	2.7
Mitigation policy priority score	8.7	15	7.9	9.9	9.5

Evaluation factors rating scales: 1 = very low, 2 = low, 3 = medium, 4 = high, 5 = very high
Note: The green rows are an average score of all the rows above the corresponding council and the orange row is the total of all the green rows above the corresponding council.
CSP: Community Strategic Plan; FSR: Financial Sustainability Rating

4.3 Challenges and barriers in mitigating GHG emissions

Q.3 What are the challenges and barriers in mitigating the local emissions:

a. From an institutional capacity perspective

b. From National Electricity Market (NEM) regulation perspective?

4.3.1 Key findings

1. The internal challenges and barriers confronting each individual council in mitigating its emissions vary subject to its institutional capacity profile.
2. The external challenges and barriers are market regulations that affect street lighting and feed-in tariffs.

4.3.2 Findings analysis

The City of Sydney rated all internal challenges and barriers as medium to very low. The only one rated as high was the external 'Barriers from energy market policy regulation'. Therefore, the following findings from the survey on the internal challenges and barriers that were rated high and very high in their course of mitigating emission targets are only from the other four councils (number in brackets is the count of rating to the item from the survey):

a. From an institutional capacity perspective (Internal):

i) Financial Capacity

- Lack of funding sources (2 X very high)
- Cost of technology due to insubstantial economies of scale (2 X very high)

ii) Leadership

- Lack of interest from the council (1 X very high)
- Lack of interest and support from the council senior management (1 X high)

iii) Skills and knowledge

- Lack of technical information (1 X high)
- Insufficient expertise and capacity for project implementation and maintenance (1 X high)

b. From a national climate policy perspective (External):

i) Barriers from energy market policy regulation (2 X very high, 2 X high)

ii) Lack of clear direction from federal / state climate change policies (1 X very high)

The above findings show that there are various internal challenges facing the four councils that relate to their different institutional capacity profiles. Theoretically, a challenge would only exist when an organisation is required to achieve a goal beyond its capacity to handle effectively. Therefore, the findings on institutional capacity profiles in Q.2 offer an explanation on the survey result from Sydney that none of the above internal challenges has significant impact on them, due to its capacity strength in all areas. From this perspective, Table 4-5 can provide a mapping of an individual council's capacity profile to demonstrate their relative strengths and weaknesses which could uncover the potential challenges in relationship to their area of capacity weaknesses.

The main barrier is found to be the 'Barriers from energy market policy regulation', which is external to all councils and cannot be resolved effectively to make significant Scope 3 emission reduction. Table 4-2 identifies that the annual cost of street lighting as a percentage of the total electricity expenditure for the five councils annually ranges from 25% in Willoughby to 59% in Bankstown. The percentages of its contribution to councils' total emissions range from 31% for the City of Sydney to 52% for Ku-ring-gai. This offers a clue to one of the factors behind the review of the mitigation targets of both Willoughby and Ku-ring-gai to exclude the street lighting.

The interview discussions revealed that all five councils are a part of the Southern Sydney Regional Organisation of Councils (SSROC) consortium in dealing with the issue, and to some councils the progress is unsatisfactory. To show the magnitude of the street lighting as a significant barrier to cutting councils' emissions, one needs to look no further than the figure reported in Sydney's Green Report on their three-year project in public lighting mentioned in Q.2:

> *'Sydney is one of the largest users of street lighting in NSW with 22,000 lights. Of these, 13,500 are maintained by Ausgrid and 8,500 by the City.'*

Another barrier from the market regulation is the new unsubsidised feed-in tariffs range for 2014/15 being set to just 5.0–9.6 cents per kWh for export to the grid (IPART, 2014), whereas the market cost is 27 cents per kWh when drawing from it. This has made the site with a high feed-in usage pattern unviable economically. North Sydney, for example, indicated during an interview that they have many properties fall in this category, which has discouraged their implementation of such projects.

4.4 Financial evaluation processes

Q.4 What financial evaluation processes were adopted in ensuring the economic viability of the alternative energy projects and if the accounting of the projects' performance was tracked and aggregated?

4.4.1 Key findings

1. Most energy reduction projects undertaken by councils fall below the threshold of $100,000, and therefore extensive financial assessments are not carried out.
2. Detailed financial assessments on large capital projects tend to occur greater than the $400,000 threshold and are undertaken by an external consultant.
3. A review of consultant project assessment reports found that cost benefit analysis is limited to measuring criteria of NPV, IRR and simple payback, rather than discounted payback.
4. Councils generally lack specific expertise to evaluate the financial viability of energy reduction projects.

4.4.2 Findings analysis

In order to gain knowledge on the financial evaluation processes in the councils, survey questions were posted to gain information for the following relevant areas from the financial managers / officers:

- Do the energy reduction projects undergo an internal viability assessment?
- What internal financial model is used in the evaluation?
- Is any ex-post project performance tracking in place?

However, only four councils had returned financial manager part of the survey, as City of Sydney had only completed the environmental manager part of the survey. Even with those returned financial manager survey, none of them was filled out by the financial manager. They were completed by senior environmental manager / officers instead.

The findings to the above question areas are summarised in Table 4-6, where the finding on the 'Evaluation by consultant' was by way of interview discussion rather than from the survey:

Table 4-6 Economic evaluation, financial model and performance tracking

	Bankstown	City of Sydney	Ku-ring-gai	North Sydney	Willoughby
Internal viability assessment	Yes	Yes	Yes	Yes	Yes
Internal financial model used	No	Yes	No	No	No
Evaluation by Consultant	Yes	Yes	Yes	Yes	Yes
Ex-post performance tracking	No	Yes	No	No	No

4.4.2.1 Internal viability assessment

Table 4-6 shows that all councils had an 'internal viability assessment' process to determine energy reduction projects. The type of assessment varied across the councils, as did the financial threshold for assessment. Councils also used an 'internal viability assessment' as part of their economic appraisal of projects. This also varied across the councils with respect to the section carrying out the assessment, the financial threshold, and the viability criteria. For example, in Bankstown City Council, the environmental officer carries out the economic feasibility study (threshold not specified). This is subsequently reviewed by their Budget Review Panel on annual basis. The Panel works as an internal filter, based on advice from the financial manager before the annual list of all projects can be approved by the executive committee.

At Ku-ring-gai Council, the environmental team is responsible for technical analysis and evaluation along with the Operations and Strategic Projects department. General cost and benefit analysis is performed on projects over $100,000, and NPV or IRR is used to evaluate project viability. The discount rate, projected electricity price rise and maintenance costs are included in the financial model. For projects below $100,000, a payback criterion of 10 years or less is considered to be viable. In North Sydney Council, for projects over $150,000, quotes are acquired to demonstrate payback period as criteria. For large scale works, technical and financial modelling is conducted by consultants. The environmental officer of Willoughby

Council performs initial financial assessment on projects over $20,000 that are ‘politically sensitive’, or ‘community based’. This assessment is then reviewed by the Council’s senior management team.

The City of Sydney Council has the most sophisticated and stringent financial control process. Any project above $60,000, or that has cross-divisional impacts, is subject to their internal established project management structure process to ensure no overlapping or duplication of projects before it is approved by a committee to proceed. PV projects require assessment of key criteria including NPV and payback. Analysis must also include an assessment against the reasonable cost of carbon abatement.

4.4.2.2 Internal financial model and consultant services

Only one council, City of Sydney, had an internal financial model (adopting Discounted Cash-Flow model[21]) to assist in the assessment of capital projects (Table 4-6). Within the council, dedicated staff were assigned to carry out a discounted cash-flow financial assessment for the project in supplement to a more detailed economic, environmental and social benefits evaluation. For project sizes exceeding a certain limit (value not provided), an external consultant report would be procured. Therefore, all councils engaged external consultants to undertake financial assessments for larger and more expensive projects. The financial threshold for this assessment varied across all councils, but was generally above $400,000. The financial assessments that were performed by an external consultant typically involved some form of cost/benefit analysis using criteria of NPV, IRR and simple payback.

Based on the following observations, the study found a general lack of financial evaluation expertise within the environmental department of the participating councils related to alternative energy generation projects:

- None of the financial staff had participated in the survey and interview of this study, even though there was effort to be inclusive of them. This can be interpreted as a lack of close engagement between the financial and environmental staff in the evaluation and decision-making processes of the financial viability of their alternative energy

[21] Refer to Short et al. (1995) manual for details on the cash-flow model.

projects. Since most projects fell below certain monetary thresholds, thus requiring less scrutiny from the financial department.

- All councils except City of Sydney had confirmed during interview that there was no accessible financial evaluation tool available internally. City of Sydney was reluctant to disclose its tool that was regarded as an intellectual property.
- All councils engage external consultant as an outsourcing practice in financial assessment of their big alternative energy projects.
- All freely available tools were not comprehensive and adaptable due to the hidden calculation formula.
- The responses from the participating councils to the Focus Group workshop presentation of the model were very positive.

Based on these findings a financial evaluation model has been developed with the aim of assisting councils to improve their internal financial expertise capacity (refer to Section 6 for the model).

4.4.2.3 Ex-post performance tracking

The ex-post performance tracking of alternative energy projects to validate both system and financial performance against its assessments is limited. It may be improved in future for three councils with the help of new software. Currently, it is clear that the City of Sydney is the only council that is equipped to handle the demand of the project evaluation and performance tracking, with the help of an established data management platform together with the newly completed PV systems that are fully equipped with data capturing and reporting capabilities.

To conclude this section, the findings to the above four questions have highlighted and confirmed the working of various elements of institutional capacity found in this study. The financial capacity to fund the right projects requires: robust financial analysis; financial resources; commitment to policy; internal reporting systems to validate modelling against actual performance; and more broadly developed technical skills and financial literacy within and between the environmental and financial departments of council.

5 Discussions and recommendations

5.1 Main findings

This study has sought to uncover the challenges and barriers facing local government in financing greenhouse mitigation initiatives. Following are the main findings:

1. Setting targets and tracking progress is a challenge to most councils, and the challenges and barriers to mitigate emissions are different across each council.
2. The priority to fund projects that deliver against climate change mitigation targets is informed by a council's financial resources, leadership at the political (elected councillors) and executive levels and staff knowledge and skills.
3. Initial financial assessments of energy projects tend to be undertaken by environmental staff who have a good working knowledge of the technical aspects of the projects but, in general, a limited expertise in the financial evaluation area.
4. The market regulation affecting street lighting is seen as a significant barrier to all councils in addressing one of their major emissions sources.

5.1.1 Institutional capacity profiles and challenges

Figure 5-1 is a graphical representation of the five councils' institutional capacity profiles plotted from Table 4-5. The chart shows each capacity element's strength and weakness mapped as an institutional capacity profile of each individual council. The City of Sydney demonstrates the strongest capacity across all areas. It is, however, not typical of a metropolitan council due to its high staffing, financial resources, rates, property base and access to funding. In this regard, comparing this council to the other councils in the study has limited utility.

Findings from Q.3 show that the City of Sydney rated all challenges listed below as medium to very low. The only high rating from their survey was the 'Barriers from Energy market policy regulation', upon which they do not have direct influence. From an organisational perspective, the identified challenges and barriers are, in effect, a reflection of its weak area (lack of certain capacity) that posts limitations on its ability to achieve its chosen goal. Therefore, the following listed challenges and barriers do not constrain Sydney as much as they do other councils, which have very different institutional capacity profiles, as shown in Figure 5-1.

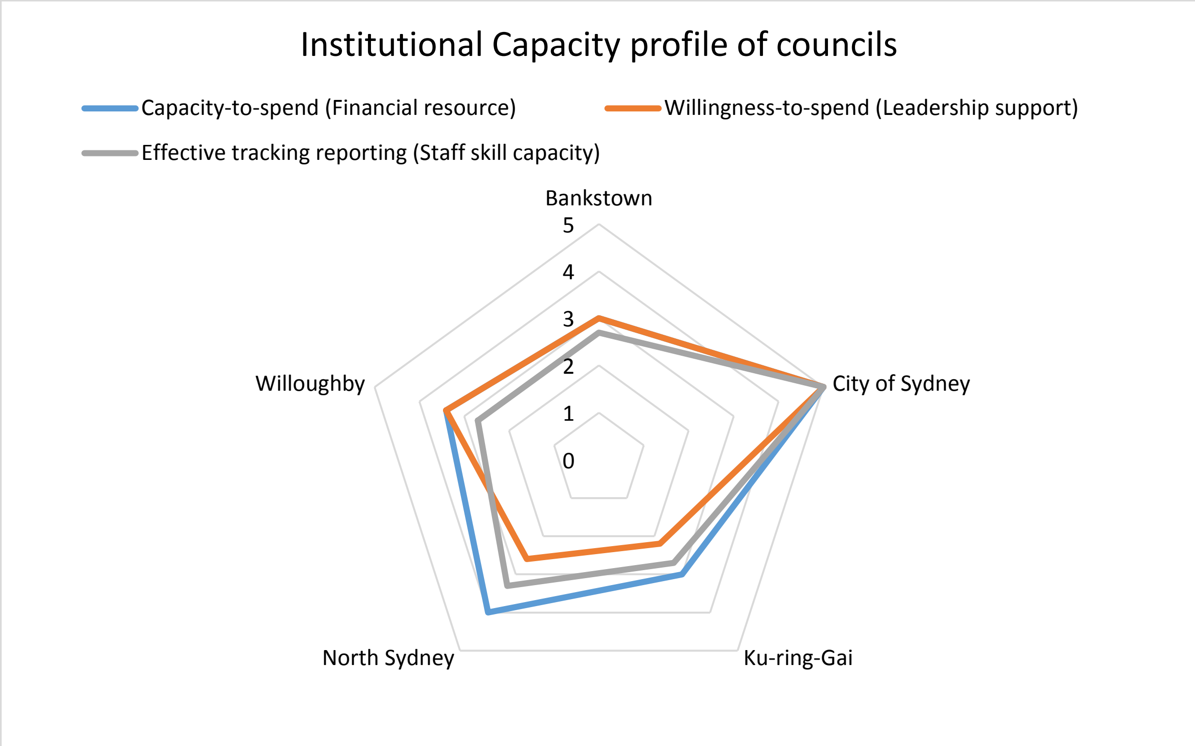

Figure 5-1 Comparison of councils' Institutional Capacity profile

5.1.2 Challenges and barriers identified by the four councils

The following main challenges identified by the four councils (excluding Sydney Council) are grouped according to their nature against institutional capacity elements:

Financial Capacity

- Lack of funding sources
- Cost of technology due to insubstantial economies of scale

Leadership

- Lack of interest from the council
- Lack of interest and support from the council senior management

Skills and knowledge

- Lack of technical information
- Insufficient expertise and capacity for project implementation and maintenance

By connecting this result back to Figure 5-1, theoretically, councils that are weak in financial resources would experience the challenges listed under the financial capacity. The same deduction can apply to the challenges linked to leadership and staff capacity. It becomes easy to explain other challenges relating to the various elements of the institutional capacity, for example, when the willingness-to-spend is low with a council, this would likely reflect the lack of leadership / management support as its challenge. When the staff skill and knowledge is identified as a challenge to a council, it would be reflecting a lack of capacity in tracking and reporting. However, the external barrier from the 'Energy market policy regulation' was identified as a common barrier to all councils, including City of Sydney, and reflects the market regulation with which councils have no influence, regardless of their institutional capacity.

5.1.3 Comparison with findings from other literature

Following is a list of challenges and barriers uncovered through a literature review:

1. Financial constraints of NSW local governments (Dollery, 2005; Dollery et al., 2006).
2. Institutional capacity constraints (Pillora, 2011; ILGRP, 2013; Carter, 2013; Dollery, 2014).
3. Obstacles facing local governments in street lighting (WALGA, 2011; Commonwealth of Australia, 2011c; Ironbark, 2012).

The findings of this study have confirmed the challenges and barriers confronting the local government sectors listed above. This study has contributed to the rationale and relationship between the revenue-raising capability to their financial sustainability and other institutional capacity elements that shape what the councils would likely experience as their challenges and barriers. In addition, this study has identified a general lack of energy project financial evaluation expertise in the local government sector.

5.2 Recommendations

For local governments wishing to mitigate their carbon emissions, the following recommendations are given:

1. Set a realistic emission reduction target according to institutional capacity.
2. Accept the baseline data, which may not be accurate, prior to acquiring more robust energy monitoring systems. Shifting the baseline to a later year will forgo any reduction in emission from earlier projects and it may be harder to capture the full level of commitment from senior management.

3. Implement an energy data management strategy, a set standard and regularity in tracking and reporting against the baseline, as well as annual energy use / savings in monetary terms.
4. Prioritise energy projects with a favourable energy consumption pattern (consume during sunshine) that can minimise feed-in to make projects viable.
5. Adopt a robust economic analysis and financial evaluation model to inform sound investment decision-making. The constructed financial evaluation model in Section 6 aims to enhance financial evaluation skill in the LG sector.
6. Street lighting is the biggest barrier caused by the market regulation, with monopolised and complex layers of stakeholders involved. Lobbying action at the LG Association level to raise the issue to state or national level could draw attention to the significance of street lighting as an effective strategy in national emission reduction. At the same time, the engagement of consultant experts in dealing and negotiating with various entities may bear fruit in expediting the progress.

6 Financial evaluation model for solar PV project

This financial evaluation model has been constructed to address the gap in technical knowledge and experience in assessing energy reduction projects by local government. The aim of the model is to improve the financial literacy and competency of staff in the local government sector, particularly in the environmental sections, who most often undertake the initial technical and financial assessment of projects. The model includes fundamental concepts in financial modelling such as investment cash-flow, discounted time-value and calculation formula, adopted from Short et al. (1995).

(Note: *The financial evaluation model for solar PV project was constructed in Excel Spreadsheet. All relevant spreadsheets are included in Appendix B. The two case studies used in this Chapter to demonstrate the working of the model are available through the following link to be downloaded for your examination.* *https://onedrive.live.com/redir?resid=8F11811359A67847!114&authkey=!ANky0h_ObkYFdPA&ithint=folder%2cxlsx*)

This model considers only monetary values from the perspective of the investment project, rather than including all the costs and benefits from the perspective of society such as the cost of abatement as externalities (Short et al., 1995; NSW Treasury, 2007). By varying the discount rate in the calculation, this model offers sensitivity analysis to demonstrate the impact of discount rate on the time value of the long-term capital investment. The model has been constructed primarily for rooftop solar PV technology projects. This responds to two observations: that local councils tend to invest in this technology as a priority; and that the technology itself is fast approaching grid parity in Australia (Chen and Franklin, 2011).

In developing this model, consideration was given to other free tools available online such as the Sunulator from ATA[22] and PV model from APVA[23] (APVA, 2011). However, these tools have different purposes, and are not catered specifically on the needs of the local government sector. Further, their use of macros within the spreadsheets conceals all calculation formula within the model, making them a 'blackbox' tool. For a user with strong financial literacy, this has limitations in that the function of variables is hidden and the result may not reflect the

[22] Alternative Technology Association.
[23] Australian PV Association.

particular conditions of the investment. Conversely, for those without sufficient financial literacy, they will rely, in good faith, on the result offered. A blackbox approach also limits the capacity to modify the tool. By displaying all the calculation formulae and the step-changes of introducing relevant variables in each scenario, the model can be easily understood and adapted to evaluate other projects such as energy efficiency and other technologies. However, the user does need to have a good grasp of the investment discounted cash-flow concept and the functionality of spreadsheets to ensure the adaptation is appropriate to their condition.

To demonstrate the different calculation of the small renewable energy credits (SRECs) and large renewable energy credits (LRECs), two projects with different sizes of under and over 100kW are adopted from Sydney's Town Hall PV project with 42kW and Willoughby's Solar Farm with 130kW. However, the main presentation of the scenarios is only on the Town Hall project, whereas the Willoughby project only shows one scenario, which is the LRECs for comparison purposes in order to avoid too much repetition of similar spreadsheets.

6.1 The discount rate and constant dollar

The investment of the rooftop solar PV systems usually require a large initial sum of capital to be sunk and locked in for a long period of time, whereas the cost-savings from the locally generated PV electricity offsetting the grid electricity charges are over the total lifespan of the equipment. Hence, the costs and benefits accrued are of different time values and are difficult to be quantified and compared in evaluating the viability of the investment. To facilitate the fair comparison of the different time values, all the costs incurred and the benefit of cost-savings accrued are discounted by a selected discount rate to bring them all to the present values (Short et al., 1995).

For the purpose of this model, the real discount rate is assumed to be 7%, as recommended by NSW Treasury (2007). This real discount rate, which excludes the inflationary effect, encompasses the elements of social time preference, opportunity cost of capital and cost of funds. It does not account for the financing risk and uncertainty for the capital invested. The cash flows from the energy projects are the cost-savings from offsetting the electricity charges from the grid. Since the primary motivation of the councils' renewable energy projects include conservation and sustainability purposes, a sensitivity test using real discount rates of 4% and 10% as recommended by NSW Treasury (2007) was conducted for comparison of different scenarios. Refer to subsection 6.4.3.2 for more details on sensitivity analysis.

6.2 Decision-making measuring criteria

The following financial decision-making measuring criteria are chosen as a final output in facilitating the investment analysis and decision-making:

- Net present value (NPV)
- Levelised cost of electricity (LCOE)
- Discounted payback period (DPP)
- Internal rate of return (IRR)

6.2.1 Net present value (NPV)

A positive NPV indicates an investment project is considered to be potentially viable, as the total present value of benefits exceed the total present value of the project costs. If the NPV is a negative value, the investment decision on the project will need to be reconsidered or abandoned. Since NPV is highly dependent on the discount rate adopted, and assuming a constant future condition of interest rate, sensitivity analysis is often performed to gauge the impact of changing rates and future conditions on the NPV. The results of all sensitivity analyses would give a proxy aiding in better investment decision-making (NSW Treasury, 2007; BEI, 2012).

6.2.2 Discounted payback period (DPP)

DPP accounts for the time value of the investment cost and cash-flow. It takes a longer period to recover the investment cost using DPP than the simple payback method since it does not account for the time value of capital to the investor. It offers a quick initial assessment of how long invested capital is at risk, and if the DPP exceeds the total lifecycle of the plant, which implies the investment will not be fully recovered. The risk and uncertain duration can easily be communicated and understood by the decision-maker, which makes it a popular assessment tool. When using DPP as a proxy for a project’s economic duration, care must be taken with bias against long-term in favour of short-term projects and bias against a relatively slow build-up of profits, even though the overall return may be higher (Lefley, 1996).

6.2.3 Internal rate of return (IRR)

IRR is used to evaluate the attractiveness of an investment project. The decision criteria are usually by comparing the IRR of a new project against a set minimum acceptable rate of return. The project will be viable if the IRR exceeds the minimum acceptable rate of return, which could be set to be the cost of capital. IRR also allows the ranking of projects by their overall rate of return, and the investment with the highest IRR is usually favoured. However, IRR has limited effectiveness on appraising investments that have an initial capital cost that is followed by a stream of erratic positive cash inflows (Kelleher and MacCormack, 2004). IRR also does not measure the absolute size of the investment or the return, which would favour high rates of return even if the dollar amount of the return might be very small.

6.2.4 Levelised cost of electricity (LCOE)

LCOE is interpreted as the long-run marginal cost of electricity generation of the solar PV system. Focusing on the unit cost, LCOE is different to the NPV, which focuses more on the profitability of a project by including the market electricity price and multiple uncertainties and risk factors in the equation. Hence, in the assessment process, LCOE as a measuring criteria would need to be complemented by other, more comprehensive multiple risk factor indicators. For the model, the project is considered to be at grid parity when the LCOE is equal to or below the unit price of the market electricity. The analyst also needs to be aware of the limitation that LCOE does not adequately reflect market uncertainties and dynamic pricing (IEA-OECD, 2010). Therefore, the model performs sensitivity analysis to assess the impact of the changes in key parameters on the costs of generating electricity, which is shown in Figure 6-5.

6.2.5 Considerations on using the evaluation criteria

There are no ideal financial evaluation criteria that can offer a risk-free, sure-save investment decision. Recognising the limitations of any tools or approaches, they can be used to improve environmental investment goals while minimising risk on capital. In applying the following steps, more robust decisions can be made.

1. The first consideration criterion is for the NPV to be positive. If this is satisfied, consider how long the investment capital would be at risk. That is how long an investment could

be fully recovered, as indicated by the value of the DPP. A project would be favoured if the DPP is below a set acceptable year to recover the capital.

2. The value of the IRR is only to verify and confirm if the capital rate of return is indeed above the market cost of the capital, which is the interest rate (set as a hurdle rate).
3. The LCOE can be used to justify if the timing is right for the investment to proceed. The LCOE provides a comparison of the unit cost of the electricity generated from the project to the grid market price. When LCOE is equal to or lower than the market price of electricity, it would indicate the project is at grid parity, which (in the case of the solar PV) can be interpreted as favourable for the project to be accepted.

6.3 Assumptions

The actual costs of the two case-study projects from the councils are considered sensitive to be disclosed, therefore cannot be used to demonstrate the calculation of this model. Many variables in the model can vary considerably, depending to a large extent on good estimated cost components and cash-flow involved before the assessments can be useful. In order to apply more accurate market costs under Australian conditions, the costs of the PV system used in this model are adopted from the AETA[24] latest report (BREE, 2013). Therefore, the basic assumptions of the capital costs would be similar to that of the AETA's, which include the PV panels, inverters and construction costs, whereas the O&M costs include the parts and labour, and inverter replacement reserve (replaced at operational year 10). If the real costs are available through quotation, users could enter the price and adjust the inverter cost at the tenth year in the Basic Scenario, which could then be propagated to other scenarios accordingly. The electricity price annual increase rate is assumed to be 5% in real term. This is adopted from the 'Electricity price trends report' of AEMC (2013, p.iv), where the national average annual rate of change from year 2011/12 to 2014/15 was 7% in nominal price minus an assumed 2% inflation rate.

6.3.1 Basic assumptions

- The base year 0 for the constant dollar present value is set to 2014.

[24] Australian Energy Technology Assessment report from Bureau of Resources and Energy Economics.

- A discount rate is 7% and sensitivity analysis rates are 4% and 10%, as recommended by the NSW Treasury (2007).
- The full lifecycle of PV plant is assumed to be 25 years.
- Assume all PV arrays are north-facing, inclined at latitude angle and installed on a roof area of a commercial building that generates optimum electricity to be fully utilised locally during office hours.
- Carbon price is included in electricity price for the Basic, Low and High Discount Rate scenarios, but excluded from all other scenarios.
- The depreciation value of the PV plant is half of the capital cost, which is to be written-off in 20 years (common practice in councils).
- Corporate tax rate is 30% and GST is not included in the costs.
- When Renewable Energy Credits are included, the prices are assumed to be $37 per SREC and $39 per LREC[25].
- The price range of the feed-in tariff is adopted from IPART.
- The transmission or interconnection costs are excluded.

6.4 Design of the model

The model is designed with three components: inputs, outputs and calculation modules. All the necessary data and figures required as an input to the calculation spreadsheet module are listed in the 'Inputs' module for users to enter their relevant data of planned solar PV projects. Upon data entry, the model will automatically calculate the constant present values of the NPV, LCOE, DPP and IRR, and will be presented in the 'Outputs' module. NPVs from all the scenarios are tabled and compared in the 'Charts' spreadsheet, which also holds all the sensitivity analysis charts. In order to demonstrate the Inputs, Outputs and Calculation Modules of the model, the solar PV project of Sydney Town Hall from the City of Sydney and the Westfield solar farm project from Willoughby are used as case-studies as follows:

<u>Case study 1: Sydney Town Hall —solar photovoltaics Project</u>

Sydney Town Hall is an architectural and historic icon. The building is heritage listed so the photovoltaic (PV) design was sympathetically designed to the Town Hall's form and character.

[25] This could change if the 20% RET is to be reduced and is passed by the Senate.

High efficiency PV cell panels were installed on the heritage slate roof. Installation of the panels was carefully considered to ensure no impact to the building using engineered mounting frames. This innovative mounting system cost less than budgeted, and therefore, more panels were able to be added to the system. Power generated from this project is used by Sydney Town Hall and Town Hall House.

Capacity: 48kWp

Annual output: 60MWh pa

Solar panels: 240

Annual saving: 62.4 tonnes CO2-e

6.4.1 Inputs Module – example

All the input fields are entered in this module in Table 6-1. The calculations would be performed and inserted automatically to the outputs module in Table 6-2.

Table 6-1 Inputs Module

Solar Photovoltaic (PV) Input Module			
Inputs	**Values**	**Units**	**Remarks**
Plant Capacity (Net)	48	kW	
Number of Solar Panels	240		Each panel = 200 Watt
Capital Cost (Installed cost)	3380	$/kW	Cost for Installment of Panels / per KW
Total Capital Cost	162240	2014 dollar	Total Cost of installing panels
Fixed O&M cost	25	$/kW/year	Operation and Maintenance Cost including invertor (BREE 2013)
Total O&M cost	1200	2014 $/year	
Annual Electricity Output	60	MWh/year	NREL PVWatts Calculator = 61,530 kWh/year
Annual Production Degradation	0.5	%	Decrease in Production per annum range 0.01-1%
Electricity Price (with Carbon Tax)	27	cents/kWh	Market price of electricity for council including carbon tax
Electricity Price (ex Carbon Tax)	25	cents/kWh	Market price of electricity for council excluding carbon tax
Electricity Price annual increase rate	5	%	Assumed annual increased rate
Discount Rate	7	%	Constant dollar discount rate without inflation from Treasury Report
Low Discount Rate	4	%	
High Discount Rate	10	%	
Operating years	25	years	Flexible, potentially 30 years
Percentage of PV to Total Capital Cost	50	%	
Depreciation Amount	81120	Dollar	Assume PV panel price to be 50% of total capital cost
Depreciation Rate	5	%	Assume PV panel capital cost to be written off in 20 years
Corporate Tax Rate	30	%	Corporate tax
Number of SRECs	995	RECs or STCs	https://www.rec-registry.gov.au/sguCalculatorResult.shtml
Price of each SRECs	37	Dollar	Assumed market price per SREC and are taken as initial discount from price
Price of each LRECs	39	Dollar	Assumed market price per Large Renewable Energy Credit (LREC)
Feed-in percentage of PV power	10	%	
Feed-in Tariff/kWh	8	cents/kWh	Price from IPART

6.4.2 Outputs Module – example

All the evaluation measuring criteria are automatically updated after the input module is completed. The output module shown here shows just a few examples of all scenarios mentioned in Section 6.4.3 below.

Table 6-2 Outputs Module

Output Module - Basic Scenario			Output Module - Low Discount Rate Scenario		
Outputs	**Values**	**Units**	**Outputs**	**Values**	**Units**
Net Present Value (NPV)	126,623	Dollar	**Net Present Value (NPV)**	251,123	Dollar
Levelised Cost of Electricity (LCOE)	0.26	Dollar/kWh	**Levelised Cost of Electricity (LCOE)**	0.20	Dollar/kWh
Discounted Payback Period (DPP)	13	years	**Discounted Payback Period (DPP)**	11	years
Internal Rate of Return (IRR)	13.03%		**Internal Rate of Return (IRR)**	13.03%	

Output Module - No Carbon Tax Scenario			Output Module - Depreciation Scenario		
Outputs	**Values**	**Units**	**Outputs**	**Values**	**Units**
Net Present Value (NPV)	104,190	Dollar	**Net Present Value (NPV)**	117,081	Dollar
Levelised Cost of Electricity (LCOE)	0.26	Dollar/kWh	**Levelised Cost of Electricity (LCOE)**	0.26	Dollar/kWh
Discounted Payback Period (DPP)	14	years	**Discounted Payback Period (DPP)**	13	years
Internal Rate of Return (IRR)	12.06%		**Internal Rate of Return (IRR)**	12.71%	%

6.4.3 Calculation module

The 'Calculation' Module is made up spreadsheets of all the difference scenarios in this sequence: Basic scenario, Low Discount Rate, High Discount Rate, No Carbon Tax, Depreciation, SRECs and Feed-in.

6.4.3.1 Basic, Low Discount Rate and High Discount Rate scenarios

The calculation of the electricity price includes carbon tax in all the 'Basic, 'Low Discount Rate' and 'High Discount Rate' scenarios. The only difference among these three scenarios is the use of discount rates of 7%, 4% and 10% respectively in order to demonstrate how sensitive the NPVs are to the varying discount rates. Sensitivity analysis of discount rates is explained in Section 6.4.3.2 and Figure 6-1.

Referring to Table 6-3, the 'Discounted Operating Result' column shows the running annual NPV, and the amounts in red indicate the negative value of NPV. The first year when the value turns black following the last red year indicates a positive value of NPV, which represents that all the capitals cost are recovered, therefore it is the value for DPP (Discounted Payback Period), whereas the ‘Operating Result’ column shows the normal running yearly net operating value without being discounted. This demonstrates the simple payback period as shown in the ‘Operating Result’ column, which is four years earlier than the DPP, as shown in the ‘Discounted Operating Result’ column.

Table 6-3 Basic Scenario calculation of NPV, DPP and IRR

Basic Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	162,240	162,240						-162,240			-162,240
1	1200	1,121	163,361	60,000	17,010	15,897	15,897	-147,464	-146,430	1	56,075	15,810
2	1200	1,048	164,410	59,700	17,771	15,522	31,419	-132,990	-129,859	2	52,144	16,571
3	1200	980	165,389	59,402	18,566	15,156	46,575	-118,814	-112,492	3	48,489	17,366
4	1200	915	166,305	59,104	19,397	14,798	61,373	-104,932	-94,295	4	45,091	18,197
5	1200	856	167,160	58,809	20,265	14,449	75,822	-91,338	-75,230	5	41,930	19,065
6	1200	800	167,960	58,515	21,172	14,108	89,930	-78,030	-55,257	6	38,991	19,972
7	1200	747	168,707	58,222	22,120	13,775	103,705	-65,002	-34,338	7	36,258	20,920
8	1200	698	169,406	57,931	23,110	13,450	117,155	-52,251	-12,428	8	33,717	21,910
9	1200	653	170,058	57,642	24,144	13,133	130,287	-39,771	10,515	9	31,353	22,944
10	1200	610	170,668	57,353	25,224	12,823	143,110	-27,558	34,539	10	29,156	24,024
11	1200	570	171,238	57,067	26,353	12,520	155,630	-15,608	59,692	11	27,112	25,153
12	1200	533	171,771	56,781	27,532	12,225	167,855	-3,916	86,025	12	25,212	26,332
13	1200	498	172,269	56,497	28,764	11,936	179,791	7,522	113,589	FALSE	23,444	27,564
14	1200	465	172,735	56,215	30,051	11,654	191,445	18,711	142,440	FALSE	21,801	28,851
15	1200	435	173,169	55,934	31,396	11,379	202,825	29,655	172,636	FALSE	20,273	30,196
16	1200	406	173,576	55,654	32,801	11,111	213,936	40,360	204,238	FALSE	18,852	31,601
17	1200	380	173,956	55,376	34,269	10,849	224,784	50,829	237,307	FALSE	17,531	33,069
18	1200	355	174,311	55,099	35,803	10,593	235,377	61,066	271,909	FALSE	16,302	34,603
19	1200	332	174,643	54,823	37,405	10,343	245,720	71,077	308,114	FALSE	15,159	36,205
20	1200	310	174,953	54,549	39,079	10,099	255,819	80,866	345,993	FALSE	14,097	37,879
21	1200	290	175,243	54,277	40,827	9,860	265,679	90,436	385,620	FALSE	13,109	39,627
22	1200	271	175,513	54,005	42,654	9,628	275,307	99,793	427,075	FALSE	12,190	41,454
23	1200	253	175,767	53,735	44,563	9,400	284,707	108,940	470,438	FALSE	11,335	43,363
24	1200	237	176,003	53,467	46,557	9,179	293,886	117,883	515,795	FALSE	10,541	45,357
25	1200	221	176,224	53,199	48,641	8,962	302,848	126,623	563,236	FALSE	9,802	47,441
Total	Discounted total cost =	176,224		1,413,357			NPV=	126,623		Discounted total electricity generated=	669,961	
											IRR=	13.03%

6.4.3.2 Sensitivity analysis of discount rates

As demonstrated in Figure 6-1, the NPV is highly sensitive to the value of the discount rate. The NPV is in inverse relationship to the discount rate. The lowest discount rate of 4% generates the highest NPV, which means the highest return to the capital investment. Even the highest discount rate still yields positive NPV, which indicates that the project is still viable. At the same time, the DPP is about five years earlier than the highest discount rate of 10%. Therefore, choosing the right discount rate has a material impact on the evaluation and decision outcome. In the case of government projects dealing with conservation and renewable energy systems, an option of adopting lower discount rate sometimes could be justified in favour of the project (Short et al., 1995).

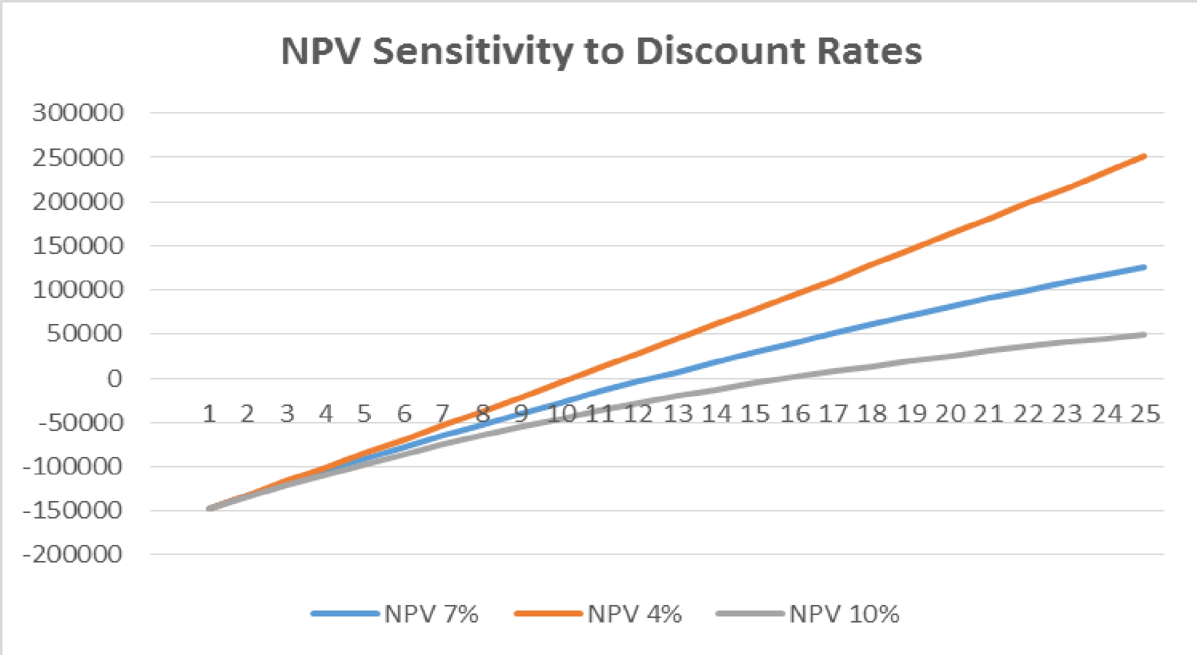

Figure 6-1 NPV sensitivity analysis

6.4.3.3 Other scenarios

The calculation of all other scenarios uses a 7% discount rate and excludes the carbon tax from the electricity price. Each of these scenarios is a step-change from the 'Basic Scenario' as well as the previous scenario by incorporating more variable elements into the calculation. Therefore, a comparison of all the NPVs from different scenarios offers a sensitivity analysis of the impact of different variables to the result of the NPVs. Table 6-2 shows a scenario incorporating elements such as the depreciation of the capital components of PV and Small Renewable Energy Credits (SRECs).

This scenario is shown here in order to demonstrate the calculation of the SRECs, which is different to the Large Renewable Credits (LRECs as shown in Table 6-4) of the Westfield solar farm of Willoughby council's case-study, which is over 100kW in size and falls under the rule of the LRECs. The SRECs is a government financial incentive for owners to install an eligible small-scale system below 100kW, such as solar PV. The small-scale systems will create renewable energy certificates for every megawatt hour of power it generates over a 15-year period, which can provide an up-front discount for the systems from the PV retailer. In a way, this would reduce the initial capital investment, as demonstrated in this scenario in the 'Small Renewable Energy Credits' column of Table 6-4.

For more examples of other scenarios, refer to Appendix B.

Table 6-4 SRECs scenario

SRECs Scenario													
Year	Capital and Fixed O&M Cost $	Small Renewable Energy Credits	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	995	125,425	125,425			81,120						-125,425
1	1200		1,121	126,546	60,000	15,750	1,217	15,857	15,857	-110,690	1	56,075	15,767
2	1200		1,048	127,595	59,700	16,455	1,217	15,435	31,292	-96,303	2	52,144	16,472
3	1200		980	128,574	59,402	17,191	1,217	15,026	46,318	-82,256	3	48,489	17,208
4	1200		915	129,490	59,104	17,960	1,217	14,630	60,949	-68,541	4	45,091	17,977
5	1200		856	130,345	58,809	18,764	1,217	14,246	75,195	-55,151	5	41,930	18,781
6	1200		800	131,145	58,515	19,604	1,217	13,874	89,068	-42,076	6	38,991	19,621
7	1200		747	131,892	58,222	20,481	1,217	13,512	102,581	-29,311	7	36,258	20,498
8	1200		698	132,591	57,931	21,398	1,217	13,162	115,743	-16,848	8	33,717	21,415
9	1200		653	133,243	57,642	22,355	1,217	12,822	128,564	-4,679	9	31,353	22,372
10	1200		610	133,853	57,353	23,356	1,217	12,491	141,056	7,202	FALSE	29,156	23,372
11	1200		570	134,423	57,067	24,401	1,217	12,171	153,226	18,803	FALSE	27,112	24,418
12	1200		533	134,956	56,781	25,493	1,217	11,859	165,086	30,130	FALSE	25,212	25,510
13	1200		498	135,454	56,497	26,634	1,217	11,557	176,643	41,189	FALSE	23,444	26,650
14	1200		465	135,920	56,215	27,825	1,217	11,263	187,906	51,986	FALSE	21,801	27,842
15	1200		435	136,354	55,934	29,071	1,217	10,978	198,883	62,529	FALSE	20,273	29,087
16	1200		406	136,761	55,654	30,372	1,217	10,700	209,583	72,822	FALSE	18,852	30,388
17	1200		380	137,141	55,376	31,731	1,217	10,430	220,014	82,873	FALSE	17,531	31,747
18	1200		355	137,496	55,099	33,151	1,217	10,168	230,182	92,686	FALSE	16,302	33,167
19	1200		332	137,828	54,823	34,634	1,217	9,913	240,095	102,267	FALSE	15,159	34,651
20	1200		310	138,138	54,549	36,184	1,217	9,665	249,760	111,622	FALSE	14,097	36,201
21	1200		290	138,428	54,277	37,803		9,130	258,890	120,462	FALSE	13,109	36,603
22	1200		271	138,698	54,005	39,495		8,915	267,804	129,106	FALSE	12,190	38,295
23	1200		253	138,952	53,735	41,262		8,704	276,508	137,557	FALSE	11,335	40,062
24	1200		237	139,188	53,467	43,109		8,499	285,007	145,819	FALSE	10,541	41,909
25	1200		221	139,409	53,199	45,038		8,298	293,305	153,896	FALSE	9,802	43,838
Total	Discounted total cost =		139,409		1,413,357				NPV=	153,896	Discounted total electricity generated=	669961.317	
												IRR=	16.13%

6.4.3.4 Sensitivity Analysis of NPVs

The following Table 6-5 compares all the running yearly NPVs of different scenarios. The number of years in red shows the Discounted Payback Period (DPP), which is also further elaborated in Figure 6-2. The comparison shows that the most favourable DPP is the 10 years from the SRECs scenario, whereas the 'Low Discount Rate' generates the most return of $251,123 to the project. The chart clearly shows that there is a parallel confluence of NPVs in the middle ground of value with exceptions to the two extremes of the 'Low Discount Rate' and ‘High Discount Rate’. This is a further confirmation of the importance of the discount rate, which is crucial in the evaluation process, hence the need to be realistic in reflecting the current and anticipated trends of the cost of capital involved.

Table 6-5 Sensitivity analysis of NPVs

Comparison of NPVs							
Year	**NPV 7%**	**NPV 4%**	**NPV 10%**	**NPV - No Carbon Tax**	**NPV-Depreciation**	**NPV-Depreciation n SRECs**	**NPV - Feed-in**
1	-147464	-147038	-147867	-148642	-147505	-110690	-111713
2	-132990	-131717	-134172	-135318	-133118	-96303	-98351
3	-118814	-116278	-121124	-122264	-119071	-82256	-85330
4	-104932	-100723	-108695	-109478	-105356	-68541	-72640
5	-91338	-85053	-96857	-96955	-91966	-55151	-60272
6	-78030	-69269	-85584	-84691	-78891	-42076	-48218
7	-65002	-53371	-74848	-72684	-66126	-29311	-36468
8	-52251	-37362	-64627	-60929	-53663	-16848	-25015
9	-39771	-21242	-54897	-49422	-41494	-4679	-13851
10	-27558	-5013	-45635	-38159	-29613	7202	-2968
11	-15608	11326	-36819	-27136	-18012	18803	7642
12	-3916	27773	-28429	-16350	-6685	30130	17986
13	7522	44328	-20444	-5796	4374	41189	28070
14	18711	60989	-12847	4530	15171	51986	37902
15	29655	77756	-5618	14631	25714	62529	47489
16	40360	94628	1259	24513	36007	72822	56836
17	50829	111604	7802	34178	46058	82873	65950
18	61066	128685	14025	43631	55871	92686	74837
19	71077	145870	19945	52876	65452	102267	83503
20	80866	163157	25576	61916	74807	111622	91953
21	90436	180547	30931	70756	83647	120462	99900
22	99793	198039	36023	79400	92291	129106	107661
23	108940	215632	40866	87851	100742	137557	115242
24	117883	233327	45471	96113	109004	145819	122645
25	126623	251123	49849	104190	117081	153896	129875

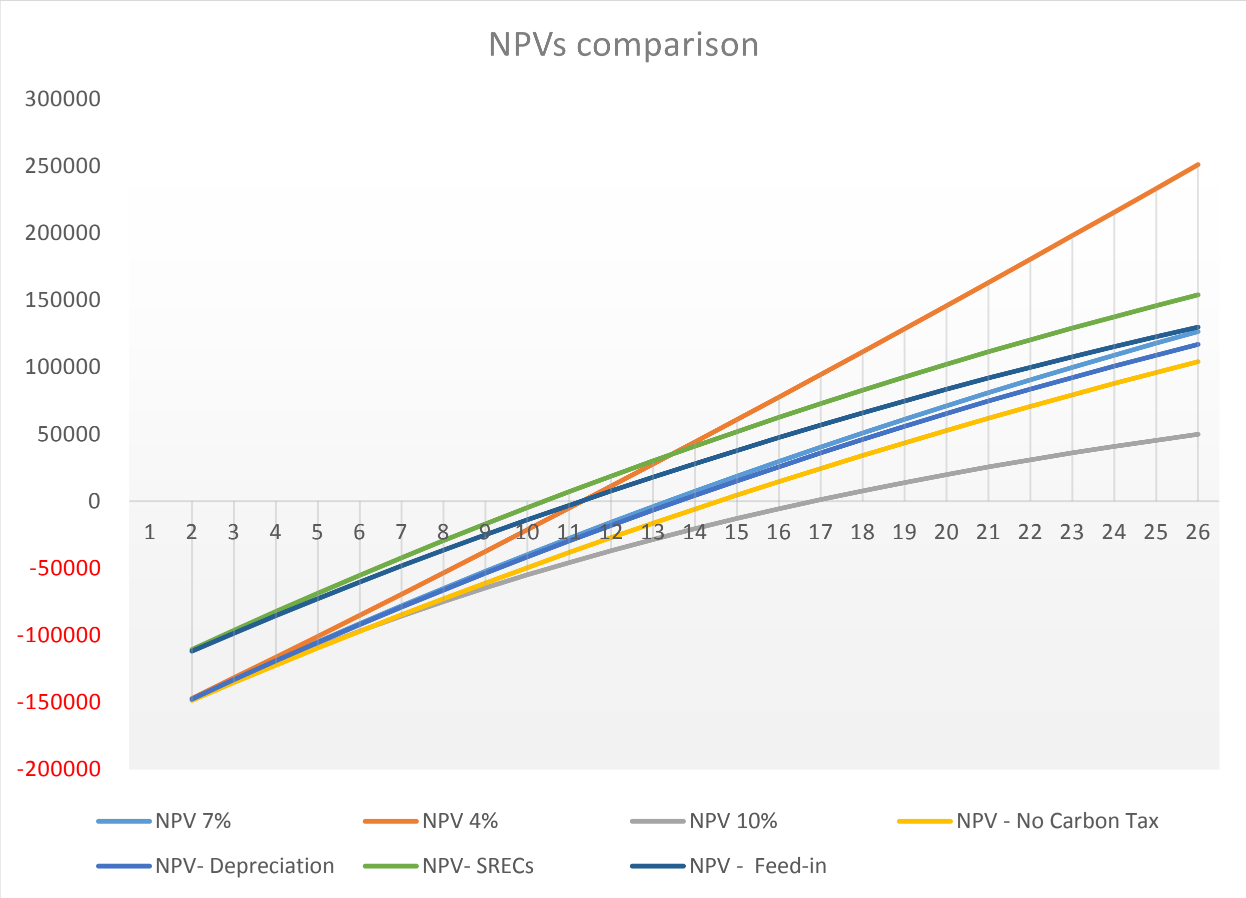

Figure 6-2 Sensitivity analysis chart for NPVs

6.4.3.5 Sensitivity Analysis of the LCOE

The following chart shows the value of all LCOE from the different scenarios. The LCOE is the sensitively response to the interest rate as well as the inclusion of depreciation, the RECs and feed-in factors of 10% in the calculation. These three show a more favourable unit cost of electricity of \$0.20–\$0.21 as compared to other scenarios ranging from \$0.26 to \$0.33. In this case, the 10% discount rate scenario will not be considered even if NPV is positive, as the LCOE is higher than the grid price.

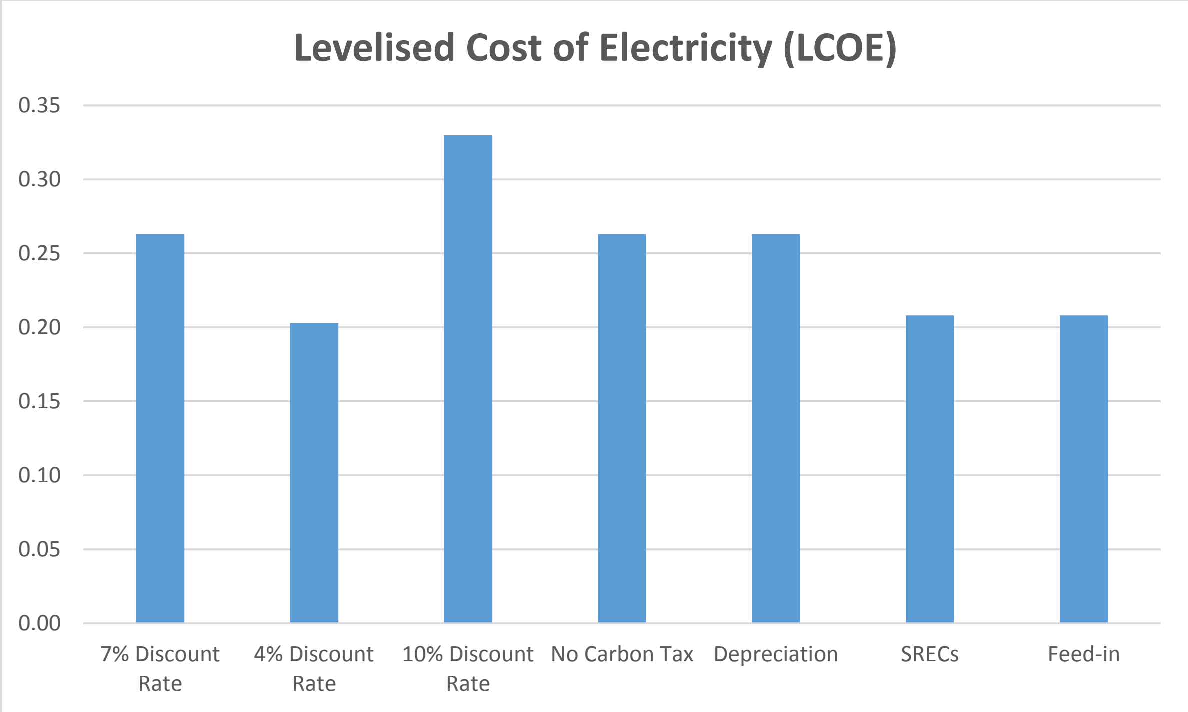

Figure 6-3 Comparing all LCOEs

<u>Case study 2: LRECs calculation of Westfield Solar Farm PV project</u>

PV System Size & Generation

The proposed Stage-2 PV system has maximum capacity of around 294 new modules to the West, and 258 new modules to East of the existing Stage-1 array. This makes a total capacity of 129.72kW for the new Stage-2 PV system.

Stage-2 – Westfield Solar Farm

Estimated Number of PV Modules:	552
Rated PV Power:	129.72 kW
Annual kWh Generation:	176,624 kWh
% of Average Annual Site Consumption:	10%
Annual Greenhouse Gas Savings (tonnes CO_2/year):	174.4 tCO_2/year

The showcase of this project from Willoughby is only to demonstrate the different calculation between the SRECs presented in the Town Hall case study above and the LRECs shows in the 'Large Renewable Energy Credits' column of Table 6-6.

The large-scale Renewable Energy Credits (LRECs) is an Australian Government scheme designed to encourage the large-scale generation of electricity from sustainable and renewable sources. Large renewable power generation systems can create renewable energy certificates for every megawatt hour of power generated on an annual basis, which can then be sold to electricity retailers to cover their carbon emission obligation. The retailers are to surrender the LRECs to the Clean Energy Regulator each year (Commonwealth of Australia, 2011a; 2011b).

Table 6-6 LRECs calculation for large-scale PV system

LRECs Scenario													
Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Large Renewable Energy Credits	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400				219,700						-439,400
1	3250	3,037	442,437	176,624	46,364	6,864	3,296	52,826	52,826	-389,612	1	165,069	53,273
2	3250	2,839	445,276	175,741	48,439	6,825	3,296	51,148	103,973	-341,303	2	153,499	48,484
3	3250	2,653	447,929	174,862	50,606	6,786	3,296	49,539	153,513	-294,416	3	142,740	50,652
4	3250	2,479	450,408	173,988	52,871	6,747	3,296	47,996	201,509	-248,900	4	132,735	52,916
5	3250	2,317	452,726	173,118	55,237	6,747	3,296	46,543	248,052	-204,674	5	123,431	55,282
6	3250	2,166	454,891	172,252	57,709	6,708	3,296	45,119	293,172	-161,720	6	114,779	57,754
7	3250	2,024	456,915	171,391	60,291	6,669	3,296	43,752	336,923	-119,992	7	106,734	60,337
8	3250	1,892	458,807	170,534	62,989	6,630	3,296	42,437	379,360	-79,447	8	99,252	63,035
9	3250	1,768	460,575	169,681	65,808	6,591	3,296	41,173	420,533	-40,042	9	92,295	65,853
10	3250	1,652	462,227	168,833	68,753	6,552	3,296	39,956	460,489	-1,737	10	85,826	68,798
11	3250	1,544	463,771	167,989	71,829	6,513	3,296	38,786	499,275	35,504	FALSE	79,810	71,875
12	3250	1,443	465,214	167,149	75,044	6,513	3,296	37,675	536,950	71,737	FALSE	74,216	75,089
13	3250	1,349	466,562	166,313	78,402	6,474	3,296	36,588	573,538	106,976	FALSE	69,014	78,448
14	3250	1,260	467,823	165,482	81,911	6,435	3,296	35,540	609,078	141,256	FALSE	64,177	81,956
15	3250	1,178	469,001	164,654	85,576	6,396	3,296	34,529	643,608	174,607	FALSE	59,678	85,622
16	3250	1,101	470,102	163,831	89,406	6,357	3,296	33,554	677,162	207,061	FALSE	55,495	89,451
17	3250	1,029	471,130	163,012	93,407	6,357	3,296	32,626	709,788	238,658	FALSE	51,605	93,452
18	3250	962	472,092	162,197	97,586	6,318	3,296	31,717	741,505	269,413	FALSE	47,988	97,632
19	3250	899	472,991	161,386	101,953	6,279	3,296	30,838	772,343	299,352	FALSE	44,625	101,999
20	3250	840	473,831	160,579	106,516	6,240	3,296	29,990	802,333	328,502	FALSE	41,497	106,561
21	3250	785	474,615	159,776	111,282	6,201		28,374	830,707	356,091	FALSE	38,588	108,032
22	3250	734	475,349	158,977	116,262	6,162		27,633	858,340	382,990	FALSE	35,883	113,012
23	3250	686	476,035	158,182	121,465	6,162		26,923	885,262	409,227	FALSE	33,368	118,215
24	3250	641	476,675	157,391	126,901	6,123		26,225	911,487	434,812	FALSE	31,029	123,651
25	3250	599	477,274	156,604	132,579	6,084		25,549	937,036	459,762	FALSE	28,854	129,329
Total	Discounted total cost =	477,274		4,160,546					NPV=	459,762	Discounted total electricity generated=	1,972,187	
												IRR=	13.94%

7 Conclusion

The aim of this study was to identify the challenges and barriers confronting NSW local governments through investigating their economic decision-making processes in evaluating and financing their GHG abatement energy projects. This study has uncovered the following key challenging elements facing local governments while financing their emission abatement initiatives:

1. Even though the baseline year varies across each council, the mitigation targets are consistent with national RET. Progress against the targets remain slow and may reflect a lower institutional capacity to prioritise expenditure towards this policy initiative. Further there are challenges in tracking and reporting energy use and greenhouse gas emissions due to limited capacity in staff and data management systems.
2. There is no national, state or local standard format or procedure in tracking and reporting of emissions. This limits meaningful comparative analysis between councils as well as reporting the aggregated contribution from the local government sector.
3. The priority of climate change mitigation policy and decisions on targets in councils is positively related to their underlying spending-capacity and willingness-to-spend dynamics.
4. The frontline environmental staff are skilful and knowledgeable with the technical aspects of energy reduction projects. However, an initial financial assessment of projects tends to be undertaken by environmental staff who rely on simple models, reflecting their limited expertise in this area.
5. Street lighting is the main barrier contributing significantly to councils' cost and emissions.

This study found that local governments do respond to climate change policy set at the national level. Therefore, good policy-setting on both the national target and standard tracking and reporting framework would enhance operational capacity for local government. The City of Sydney, enabled by its strong institutional capacity and financial power, is the only exception of the councils studied, being capable of setting targets beyond the national level to be among their global peers. Most councils in NSW are generally small, affecting the staff capacity constraint. The discussion and findings on economic and financial evaluation framework, complemented with the constructed financial model from this study, would benefit councils that need to improve their staff capacity in relation to the investment appraisal of alternative energy projects. In an increasingly capital and carbon-constraint, future world, this enhanced expertise of staff financial capability could lead to a more effective capital performance while investing in long-term alternative energy projects. Finally, the external factor of street lighting is best addressed at a state and federal level, such as re-introduction of the CEEP[26] nationwide, for it to be more economical and effective.

Two areas arising from this study require further research. The first is focused on the need to develop an effective and standardised format to track and report on progress against greenhouse gas emissions. This would build on earlier endeavours of the CCP program and would be informed by the newer generations of energy data management and reporting software. Such reporting would enable all councils across Australia to compare their emission profiles, and provide the opportunity to share in comparative data on the performance of specific technologies and strategies. This peer-to-peer learning is essential to inform the technical, financial capacity and environmental performance of this sector. The second area for review is to expedite mechanisms to enable local government to directly influence their street lighting networks. Such a strategy must consider the commercial realities of a corporatised and privatised street lighting / energy provider, yet reflect the direct cost, liability and local service expectations of councils and their communities.

[26] Commonwealth Energy Efficiency Program.

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Appendix A: Survey questionnaire and interview questions

Questionnaire filling explanations

- This questionnaire is for **environmental manager or officer** who can provide information relating to the greenhouse gas abatement and alternative energy projects undertaken in your council.

- Please provide your name and job title here:
  Name:
  Job Title:

- This questionnaire consists of 23 questions with 'checkbox' and simple logic to be followed.

- Unless it is a 'Yes/No' or a 'rating' checkbox you can choose more than one at a time.

- For the 'rating' and 'Yes/No' question please check only one option by clicking on the checkbox and then follow the 'go to Q?' in the bracket that followed your selection.

- Proceed to the next question if there is no suggestion of 'go to Q?'

- The text box under each question will expand automatically if information provided exceeds the space.

- The personal questions of Q20-Q22 are to help in tailoring the interview questions according to your responsibility, experience and duration at your council.

- If there is any question which is not clear or making sense to you, please email Grace grace.cheung@students.mq.edu.au or call me at 0421 088 420 for clarification.

- Please return the questionnaire as soon as it is finished to my email address provided above. There is no need to wait for other part to be completed.

Thank you!

A study of local governments' challenges and processes in financing their greenhouse gas abatement initiatives

Questionnaire for Environmental Manager / Officer

1. Does your council have greenhouse gas abatement and / or alternative energy targets?
   a) ☐Yes
   b) ☐No *(go to Q7)*
2. Please provide information to the following questions.
   a) What is the target?
   b) When was the target set?
   c) Which department is responsible in setting the target?

3. What was the motivation (purpose) for setting the target?

4. After the setting of the target has your council assessed and set up a baseline carbon emission or energy usage profile as an initial benchmark to monitor the progress?
   a) ☐Yes *(Please attach any document / provide link on the baseline carbon emission / energy usage profile and its respective progressive report if available?)*
   b) ☐No

5. Which department in the council is the main driver (responsible) for:
   a) Achieving the target?
   b) Monitoring the progress of the target achieved against the baseline?

6. What are the approaches being adopted by the council in achieving the set target?
   a) ☐Energy demand management by energy efficiency retrofitting program
   b) ☐Sustainable energy supply management by developing alternative energy program
   c) ☐Both of the above approaches
   d) ☐Others not listed here *(please specify)*

7. In the case of a 'No' answer to Q1, in spite of no set target, had your council in the past adopted any form of energy demand and sustainable energy supply management approaches as listed in Q6 above?
   a) ☐Yes *(please specify which approach/es)*
   b) ☐No *(go to Q15)*

8. Does your council have an internal procedure to undertake a technical assessment of the project before it is approved?

a) ☐Yes
b) ☐No *(go to Q10)*

9. Which department is responsible in carrying out the technical analysis and evaluation?

10. Does your council have an internal procedure for the energy projects to be financially assessed before the projects are approved?
    a) ☐Yes
    b) ☐No *(go to Q14)*

11. Which department is responsible in carrying out the financial analysis and evaluation?

12. Can you provide a simple list / description of the internal evaluation procedures involved? *(Alternatively, you can attach any pdf / provide link to guideline document that can provide information on the internal procedures and evaluation processes.)*

13. Are you also involved in any of these processes?
a) ☐Yes *(please specify your role and processes that you perform)*

b) ☐No *(please specify if someone else in your department is involved)*

14. What were the challenges confronting those approaches listed in Q6?
(Please rate the following challenges / barriers by inserting number '1 – 5', with ***'1' as being the least severe*** *and* ***'5' being the most severe****. Please also specify if there is a way that the challenges / barriers were overcome.)*

Rate severity '1 - 5'	Challenges / Barriers	How to overcome
	Lack of clear direction from federal / state climate change policies	
	Lack of interest from the council	
	Lack of interest and support from the council senior management	
	Barriers from Energy market policy regulation (grid connection and its cost etc.)	
	Lack of funding sources	
	Cost of technology due to insubstantial economies of scale	
	Lack of technical information	
	Insufficient expertise and capacity for project implementation and maintenance	
	Others *(please specify)*	

15. Does your council have an ongoing special rate (such as an environmental levy) on your rate payers?
    a) ☐Yes *(please specify since when, the amount and any plan to stop/increase in near future)*
    b) ☐No

16. What is the long-term climate change mitigation strategic perspective / plan in your council?

17. Does your council have a long-term master plan that encompasses a future energy development plan / program for the next 10 years and beyond?
    a) ☐Yes *(please attach pdf document / provide link to the document below)*
    b) ☐No

18. What do you consider to be the most promising renewable energy technology in the near term (next 5 – 10 years) that your council may consider in the near future?

19. Why is this particular renewable energy technology to be a preferred choice for your council?

20. What is your responsibility in the council?

21. How many years have you been in this position?

22. What position did you hold prior to your current one?

23. Is there any information you think would be useful to this study that was not being solicited in this questionnaire?
    a) ☐Yes *(please enter information in the following space. Thanks for filling in the gap)*
    b) ☐No

Questionnaire filling explanations

- This questionnaire is for **financial manager or officer** who is responsible for analysing and evaluating the technical and financial viability of the energy projects in your council.

- Please provide your name and job title here:
  Name:

  Job Title:

- This questionnaire consists of 20 questions with 'checkbox' and simple logic to be followed.

- Unless it is a 'Yes/No' or a 'rating' checkbox you can choose more than one at a time.

- For the 'rating' and 'Yes/No' question please check only one option by clicking on the checkbox and follow the 'go to Q?' in the bracket that followed your selection.

- Proceed to the next question if there is no suggestion of 'go to Q?'

- Q11 is requesting information for the financial model/s that is/are used in your council. All the columns are options for you to choose according to your model. The '**Financial Feasibility Criteria options'** listed in the table is only a suggestion of commonly adopted ones. You can choose any one or a combination of them, or even provide any that is not listed in the table to the 'Other' column.

- Q11 also requests '**mathematical calculation equation'** if any being used with its relating financial models listed in the table.

- The text box under each question will expand automatically if information provided exceeds the space.

- The personal questions of Q17-Q19 are to help in tailoring the interview questions according to your responsibility, experience and duration at your council.

- If there is any question which is not clear or making sense to you, please email Grace grace.cheung@students.mq.edu.au or call me at 0421 088 420 for clarification.

- Please return the questionnaire as soon as it is finished to my email address provided above. There is no need to wait for other part to be completed.

  Thank you!

A study of local governments' challenges and processes in financing their greenhouse gas abatement initiatives

Questionnaire for Financial Manager / Officer

1. Does the Council have procedures to ensure the economic viability of all the energy projects in your council? This may relate to a technical or financial analysis or the evaluation of the project and may depend on the amount of the project?
   a) ☐Yes *(Please attach or provide link to procedural guideline document if available internally)*
   b) ☐No

2. Does each energy project go through these evaluation processes?
   a) ☐Pre-feasibility technical analysis & evaluation *(please describe the processes)*
   b) ☐Feasibility financial analysis & evaluation *(please describe the processes)*

3. In your experience, how critical are pre-feasibility and feasibility studies in ensuring that the energy projects are financially viable?
   a) ☐Very critical
   b) ☐Critical
   c) ☐Not critical

4. What information is provided to your section for analysis and evaluation?

5. Which departments are providing the information to you?

6. Do you normally need more extra information before you can complete your evaluation processes?
   a) ☐Yes *(Please specify where do you get extra information from?)*
   b) ☐No

7. In the case of not enough information of costs and energy savings or production for new energy projects, what estimates do you consider in your calculations and or review? (For example pay back periods, rate of return, feed-in tariff)?
   a) ☐Yes
      i. How often do you use estimation?
      ii. What was the impact of the estimation in the project result when completed?
   b) ☐No

8. When you are undertaking your analysis do you:
   a) ☐Compare the project against other options?
   b) ☐Build in a risk assessment for possible cost over-runs?
   c) ☐Perform a Cost & Benefit analysis?
   d) ☐Recommend alternatives?

9. When performing a feasibility analysis and evaluation do you use a standard financial model within the council?
   a) ☐Yes *(Please enter elements of standard internal financial model in Q11 table)*
   b) ☐No

10. Do you vary the financial model or parameters of the set standard model for different energy projects and funding sources?
    a) ☐Yes (*please provide details of variation elements in Q11 table*)
    b) ☐No

11. Please provide the common elements (and variations if any) of the financial models being used in evaluating different energy projects in the following table.

Financial Model No.	Capital loan interest rate	Capital discount rate for NPV	Capital depreciation rate	**Please specify any of the following Financial Feasibility Criteria options being adopted**			
				Return on Investment Threshold	Payback Period Threshold	Benefit to Cost Ratio	Others
FM1							
FM2							
FM3							
FM4							
FM5							

Please also provide any mathematical calculation equation associated with each ***Financial Model No****. in the above table to the following space together with any basic assumptions if any (****discount rates, costs, profitability, amortization period etc****…) for the calculation in the corresponding model.*

12. Based on your analysis and evaluation outcome:
    a) ☐Are you in the position to approve or disapprove the project? *(Please specify if the approval also include making fund available to the project?)*
    b) ☐Just generate report for further decision making elsewhere *(for approval by someone else, please specify who or which department in your council)?*

13. What have been the common funding sources or arrangements adopted by your council to finance energy projects?

14. Which of the funding sources or arrangements (specified above in Q13) is the most preferred option and why?

15. Does your council have long-term funding strategy to expand energy generation or energy efficiency projects?
    a) ☐Yes *(Please specify the funding strategy)*
    b) ☐No

16. What is the ranking of the importance of the funding provision in your council for the energy program as compare to other services planning of your council?
    ☐Very high ☐High ☐Medium ☐Low ☐Very low

17. What is your responsibility in the council?

18. How many years have you been in this position?

19. What position did you hold prior to your current position?

20. Is there any information you thought would be useful to this study that was not being solicited in this questionnaire?
    a) ☐Yes *(please enter the information in the following space. Thanks for filling the gap)*
    b) ☐No

Thank you for your time and effort in completing this questionnaire

Questionnaire for project factual data – in Excel spreadsheets

Explanations

1. There are three spreadsheets that require data to be provided for:
   a. Completed Projects
   b. Planned Projects
   c. Energy Usage History
2. Some fields have drop-down menu to choose from. Please provide comment to the field if **'Other'** is selected to specify what **'Other'** is really meant for.
3. In the '**Completed Project sheet', Columns H, I and J** are related and meant to investigate if the project was being evaluated, with which financial model, then the rating of the outcome of the project as compared to the evaluation.
4. If you choose 'No' to the '**column H'** in the '**Completed Project sheet',** then no data is needed for the '**column I and J'** that followed.
5. If you choose 'Yes' to the '**column H'** in the '**Completed Project sheet'**, then the drop-down selections in '**column I'** are referring to the financial models listed in the '**Q11'** from the questionnaire for the **financial manage / officer**. Therefore, it would be easier for the same person to fill out this table.
6. Please insert rows if there is not enough provided in the table.
7. For the '**Energy Usage History'** sheet, if your council has already had a **greenhouse gas emission** and / or **energy usage profile** set up and been tracked for internal progress monitoring purposes, you can just provide the document or its link to be downloaded. In this case there is no need to fill out this table.
8. Please ignore the 'Sheet2' which contains just the drop-down tables
9. Please provide your name and job title here:
   a. Name:
   b. Job Title:

Completed Project Sheet

Please provide information required in the following table for all the energy efficiency and alternative energy projects that had been completed in your council up to now? *(Insert more row if exceeding numbers provided in the table)*

(Alternatively, you can attach any table available internally that could provide information required for this table)

Project No.	Type of Energy Project	Location and type of facility for the installation	KwH installed or saved (for EE retrofitting)	Total Capital Cost for the project	Funding Sources	Operation / maintenance cost post-project completion	Was the project evaluated ex-ante for its financial viability?	Which financial models was used in project evaluation	Rate the project outcome ex-post as compared to its financial viability evaluation	Any specific challenges encountered from project inception to delivery?	Month /Year of project started	Month /Year of project completed
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

Planned Project Sheet

1. Are there any climate change mitigation projects planned for the near term (next 5-10) in your council? If 'Yes' go to the 2. question that followed.

2. Please provide information for the planned energy projects in the following table:

Project No.	Type of Energy Project	Location and type of facility for the installation	Planned KwH to be installed or saved (for EE retrofitting)	Forecast / planned capital cost for the project	Has the project been evaluated ex-ante for its financial viability?	Evaluated ex-ante Return on Capital (in percentage) / Payback Period (in months)	Funding sources	Planned Month/Year of project start	Any specific challenges envisage for the project
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

Energy Usage History

The data require here is for tracking the carbon emission from energy / electricity used by council since the greenhouse gas or renewable energy target was setup. This information might be available easily internally from account department on the annual aggregate energy / electricity cost for council's annual financial statement. The 'Number of staff employed' is to gauge if decrease or increase of the energy used is related to the fluctuation of staff number. However, if your council has carbon emission profile setup and has been tracked ever since, then just need to attach any document or a link to such document to be downloaded. In this case, there is no need to fill out the following table.

Please provide energy usage historical data since the year the ***greenhouse gas*** or ***renewable energy target*** was first set in your council in the following table. *(only start filling in from the year when the target was first set)*

Annual Energy used	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Electricity Kwh used																			
Total cost of electricity																			
CO2 equivalent																			
Gas MJ used																			
Total cost of gas																			
CO2 equivalent																			
Number of staff employed																			

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Interview Questions

1. What is your council's position in climate change mitigation?
    a. What is the role as perceived by your council when taking actions in mitigating the climate change?
    b. Does climate change mitigation have high priority in your council?
    c. If so, what is the reason for it to be a high priority?
    d. Who is the key decision makers in climate change policies and priority setting in your council?
    e. How dependent is the climate change position of your council on those stakeholders?

2. Does the uncertain direction of climate change policies from the current Federal government have any impact to the near term and long term energy strategic planning of your council? If so, in what way?

3. Which policy changes relating to climate change would your council consider to be positive in enhancing the climate change mitigation outcome?
    a. On federal level
    b. On state level
    c. On the energy market regulation level

4. Which policy changes relating to climate change would your council consider to be negative in hampering the climate change mitigation outcome?
    a. On federal level
    b. On state level
    c. On the energy market regulation level

5. What is the most pressing issues regarding the climate change as perceived in your council?

6. Do these climate change issues interfere with other goals and responsibilities of your council?

7. What specific actions have the council taken in addressing those climate change issues?
    a. What is the reason for undertaking those specific actions?
    b. How effective are those actions?
    c. Any further actions are planned in near term?

8. What are the current major challenges and barriers to council's climate change mitigation initiatives?
    a. How do you think those barriers can be overcome?

9. Is your council's climate change mitigation agenda subject to the pressure from:
    a. Federal and state government policies?
    b. International trend and organisations?
    c. Major environmental lobby groups?

10. Has your council played an active role in the national climate change policies lobbying and shaping processes?

a. If so, how and what was the actions taken in the past?
b. What was the outcome?
c. Any planned actions in order to further improve the outcome?

11. Who are the key contacts or information sources you rely on to gain information about renewable energy (RE) technology?
    a. Individuals, organisations or information sources (e.g. websites)
    b. Are they sufficient? If not, what else do you do to acquire more information?

12. Does your council dependent on external consulting services for support when addressing the issue of RE in your council?
    a. If so, which individuals, groups, organisations do you rely on for support
    b. What type of services found to be most helpful

13. Did your council collaborate with other councils in the region for large-scale alternative energy development project? If so, what was the reason?
    a. Enhance the funding ability
    b. Minimise the financial risk
    c. Building regional capacity
    d. Enhance the regional bargaining power
    e. Overcome challenges and barriers with scale of economy

14. In the case of no regional collaborative energy development project in the past, would there be possibility of regional local governments joining force in developing an upscale RE development project in future?
    a. Which council/s would that be?
    b. What do you think would be the chance of that happening?
    c. What do you think would be the real potential of the RE capacity growth in the region as a result of such happening?

15. What would you like to see further advance of RE technology and energy policies which would improve the outcome and attract more investment from your council?
    a. What are the key enablers for more RE adoption from technology perspective?
    b. What are the key enablers for improving greenhouse abatement from policy and regulation perspectives?
    c. Can you provide some examples of cases where RE options were enabled because of factors you have mentioned above?

16. ***A set of new open questions would be inserted here to this semi-structured interview questions depending on data collected through a separate survey questionnaire before this interview. Aiming at clarifying and soliciting incomplete / unclear information. This set of questions would be project data specific and unique to each council which will be in line with the themes in the original survey questionnaire.***

17. Is there any question you thought I would have asked but I have not?

Appendix B: Financial evaluation model for solar PV project – Excel spreadsheets

Case study 1: Sydney Town Hall —solar photovoltaics Project

Sydney Town Hall is an architectural and historic icon. The building is heritage listed so the photovoltaic (PV) design was sympathetically designed to the Town Hall's form and character. High efficiency PV cell panels were installed on the heritage slate roof. Installation of the panels was carefully considered to ensure no impact to the building using engineered mounting frames. This innovative mounting system cost less than budgeted, and therefore, more panels were able to be added to the system. Power generated from this project is used by Sydney Town Hall and Town Hall House.

Capacity:	48kWp
Annual output:	60MWh pa
Solar panels:	240
Annual saving:	62.4 tonnes CO2-e

Assumptions

- The base year 0 for the constant dollar present value is set to 2014.
- A discount rate is 7% and sensibility analysis rates are 4% and 10%, as recommended by the NSW Treasury (2007).
- The full lifecycle of PV plant is assumed to be 25 years.
- Assume all PV arrays are north-facing, inclined at latitude angle and installed on a roof area of a commercial building that generates optimum electricity to be fully utilised locally during office hours.
- Carbon price is included in electricity price for the Basic, Low and High Discount Rate scenarios, but excluded from all other scenarios.
- The depreciation value of the PV plant is half of the capital cost, which is to be written-off in 20 years (common practice in councils).
- Corporate tax rate is 30% and GST is not included in the costs.
- When Renewable Energy Credits are included, the prices are assumed to be $37 per SREC and $39 per LREC.
- The price range of the feed-in tariff is adopted from IPART.
- The transmission or interconnection costs are excluded.

Solar Photovoltaic (PV) Input Module			
Inputs	**Values**	**Units**	**Remarks**
Plant Capacity (Net)	48	kW	
Number of Solar Panels	240		Each panel = 200 Watt
Capital Cost (Installed cost)	3380	$/kW	Cost for Installment of Panels / per KW
Total Capital Cost	162240	2014 dollar	Total Cost of installing panels
Fixed O&M cost	25	$/kW/year	Operation and Maintenance Cost including invertor (BREE 2013)
Total O&M cost	1200	2014 $/year	
Annual Electricity Output	60	MWh/year	NREL PVWatts Calculator = 61,530 kWh/year
Annual Production Degradation	0.5	%	Decrease in Production per annum range 0.01-1%
Electricity Price (with Carbon Tax)	27	cents/kWh	Market price of electricity for council including carbon tax
Electricity Price (ex Carbon Tax)	25	cents/kWh	Market price of electricity for council excluding carbon tax
Electricity Price annual increase rate	5	%	Assumed annual increased rate
Discount Rate	7	%	Constant dollar discount rate without inflation from Treasury Report
Low Discount Rate	4	%	
High Discount Rate	10	%	
Operating years	25	years	Flexible, potentially can operate for 30 years
Percentage of PV to Total Capital Cost	50	%	
Depreciation Amount	81120	Dollar	Assume PV panel price to be 50% of total capital cost
Depreciation Rate	5	%	Assume PV panel capital cost to be written off in 20 years
Corporate Tax Rate	30	%	Corporate tax
Number of SRECs	995	RECs or STCs	https://www.rec-registry.gov.au/sguCalculatorResult.shtml
Price of each SRECs	37	Dollar	Assumed market price per SREC and are taken as initial discount from price
Price of each LRECs	39	Dollar	Assumed market price per Large Renewable Energy Credit (LREC)
Feed-in percentage of PV power	10	%	
Feed-in Tariff/kWh	8	cents/kWh	Price from IPART

Output Module - Basic Scenario

Outputs	Values	Units
Net Present Value (NPV)	126,623	Dollar
Levelised Cost of Electricity (LCOE)	0.26	Dollar/kWh
Discounted Payback Period (DPP)	13	years
Internal Rate of Return (IRR)	13.03%	

Output Module - Low Discount Rate Scenario

Outputs	Values	Units
Net Present Value (NPV)	251,123	Dollar
Levelised Cost of Electricity (LCOE)	0.20	Dollar/kWh
Discounted Payback Period (DPP)	11	years
Internal Rate of Return (IRR)	13.03%	

Output Module - High Discount Rate Scenario

Outputs	Values	Units
Net Present Value (NPV)	49,849	Dollar
Levelised Cost of Electricity (LCOE)	0.33	Dollar/kWh
Discounted Payback Period (DPP)	16	years
Internal Rate of Return (IRR)	13.03%	

Output Module - No Carbon Tax Scenario

Outputs	Values	Units
Net Present Value (NPV)	104,190	Dollar
Levelised Cost of Electricity (LCOE)	0.26	Dollar/kWh
Discounted Payback Period (DPP)	14	years
Internal Rate of Return (IRR)	12.06%	

Output Module - Depreciation Scenario

Outputs	Values	Units
Net Present Value (NPV)	117,081	Dollar
Levelised Cost of Electricity (LCOE)	0.26	Dollar/kWh
Discounted Payback Period (DPP)	13	years
Internal Rate of Return (IRR)	12.71%	%

Output Module - SRECs Scenario

Outputs	Values	Units
Net Present Value (NPV)	153,896	Dollar
Levelised Cost of Electricity (LCOE)	0.21	Dollar/kWh
Discounted Payback Period (DPP)	10	years
Internal Rate of Return (IRR)	16.13%	

Output Module - Feed-in Scenario

Outputs	Values	Units
Net Present Value (NPV)	129,875	Dollar
Levelised Cost of Electricity (LCOE)	0.21	Dollar/kWh
Discounted Payback Period (DPP)	11	years
Internal Rate of Return (IRR)	14.94%	

Basic Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	162,240	162,240						-162,240			-162,240
1	1200	1,121	163,361	60,000	17,010	15,897	15,897	-147,464	-146,430	1	56,075	15,810
2	1200	1,048	164,410	59,700	17,771	15,522	31,419	-132,990	-129,859	2	52,144	16,571
3	1200	980	165,389	59,402	18,566	15,156	46,575	-118,814	-112,492	3	48,489	17,366
4	1200	915	166,305	59,104	19,397	14,798	61,373	-104,932	-94,295	4	45,091	18,197
5	1200	856	167,160	58,809	20,265	14,449	75,822	-91,338	-75,230	5	41,930	19,065
6	1200	800	167,960	58,515	21,172	14,108	89,930	-78,030	-55,257	6	38,991	19,972
7	1200	747	168,707	58,222	22,120	13,775	103,705	-65,002	-34,338	7	36,258	20,920
8	1200	698	169,406	57,931	23,110	13,450	117,155	-52,251	-12,428	8	33,717	21,910
9	1200	653	170,058	57,642	24,144	13,133	130,287	-39,771	10,515	9	31,353	22,944
10	1200	610	170,668	57,353	25,224	12,823	143,110	-27,558	34,539	10	29,156	24,024
11	1200	570	171,238	57,067	26,353	12,520	155,630	-15,608	59,692	11	27,112	25,153
12	1200	533	171,771	56,781	27,532	12,225	167,855	-3,916	86,025	12	25,212	26,332
13	1200	498	172,269	56,497	28,764	11,936	179,791	7,522	113,589	FALSE	23,444	27,564
14	1200	465	172,735	56,215	30,051	11,654	191,445	18,711	142,440	FALSE	21,801	28,851
15	1200	435	173,169	55,934	31,396	11,379	202,825	29,655	172,636	FALSE	20,273	30,196
16	1200	406	173,576	55,654	32,801	11,111	213,936	40,360	204,238	FALSE	18,852	31,601
17	1200	380	173,956	55,376	34,269	10,849	224,784	50,829	237,307	FALSE	17,531	33,069
18	1200	355	174,311	55,099	35,803	10,593	235,377	61,066	271,909	FALSE	16,302	34,603
19	1200	332	174,643	54,823	37,405	10,343	245,720	71,077	308,114	FALSE	15,159	36,205
20	1200	310	174,953	54,549	39,079	10,099	255,819	80,866	345,993	FALSE	14,097	37,879
21	1200	290	175,243	54,277	40,827	9,860	265,679	90,436	385,620	FALSE	13,109	39,627
22	1200	271	175,513	54,005	42,654	9,628	275,307	99,793	427,075	FALSE	12,190	41,454
23	1200	253	175,767	53,735	44,563	9,400	284,707	108,940	470,438	FALSE	11,335	43,363
24	1200	237	176,003	53,467	46,557	9,179	293,886	117,883	515,795	FALSE	10,541	45,357
25	1200	221	176,224	53,199	48,641	8,962	302,848	126,623	563,236	FALSE	9,802	47,441
Total	**Discounted total cost =**	176,224		1,413,357			**NPV=**	126,623		**Discounted total electricity generated=**	669,961	
											IRR=	13.03%

Low Discount Rate Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	162,240	162,240								-162,240
1	1200	1,154	163,394	60,000	17,010	16,356	16,356	-147,038	1	57,692	15,810
2	1200	1,109	164,503	59,700	17,771	16,430	32,786	-131,717	2	55,196	16,571
3	1200	1,067	165,570	59,402	18,566	16,506	49,292	-116,278	3	52,808	17,366
4	1200	1,026	166,596	59,104	19,397	16,581	65,873	-100,723	4	50,523	18,197
5	1200	986	167,582	58,809	20,265	16,657	82,529	-85,053	5	48,337	19,065
6	1200	948	168,531	58,515	21,172	16,733	99,262	-69,269	6	46,245	19,972
7	1200	912	169,442	58,222	22,120	16,809	116,071	-53,371	7	44,244	20,920
8	1200	877	170,319	57,931	23,110	16,886	132,957	-37,362	8	42,330	21,910
9	1200	843	171,162	57,642	24,144	16,963	149,920	-21,242	9	40,498	22,944
10	1200	811	171,973	57,353	25,224	17,041	166,961	-5,013	10	38,746	24,024
11	1200	779	172,753	57,067	26,353	17,118	184,079	11,326	FALSE	37,069	25,153
12	1200	750	173,502	56,781	27,532	17,197	201,275	27,773	FALSE	35,465	26,332
13	1200	721	174,223	56,497	28,764	17,275	218,550	44,328	FALSE	33,931	27,564
14	1200	693	174,916	56,215	30,051	17,354	235,904	60,989	FALSE	32,463	28,851
15	1200	666	175,582	55,934	31,396	17,433	253,338	77,756	FALSE	31,058	30,196
16	1200	641	176,223	55,654	32,801	17,513	270,850	94,628	FALSE	29,714	31,601
17	1200	616	176,839	55,376	34,269	17,593	288,443	111,604	FALSE	28,428	33,069
18	1200	592	177,431	55,099	35,803	17,673	306,116	128,685	FALSE	27,198	34,603
19	1200	570	178,001	54,823	37,405	17,754	323,870	145,870	FALSE	26,022	36,205
20	1200	548	178,548	54,549	39,079	17,835	341,705	163,157	FALSE	24,896	37,879
21	1200	527	179,075	54,277	40,827	17,916	359,622	180,547	FALSE	23,818	39,627
22	1200	506	179,581	54,005	42,654	17,998	377,620	198,039	FALSE	22,788	41,454
23	1200	487	180,068	53,735	44,563	18,080	395,701	215,632	FALSE	21,802	43,363
24	1200	468	180,536	53,467	46,557	18,163	413,864	233,327	FALSE	20,858	45,357
25	1200	450	180,986	53,199	48,641	18,246	432,110	251,123	FALSE	19,956	47,441
Total	Discounted total cost =	180,986		1,413,357			NPV=	251,123	Discounted total electricity generated=	892,086	
										IRR=	13.03%

High Discount Rate Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	162,240	162,240								-162,240
1	1200	1,091	163,331	60,000	17,010	15,464	15,464	-147,867	1	54,545	15,810
2	1200	992	164,323	59,700	17,771	14,687	30,151	-134,172	2	49,339	16,571
3	1200	902	165,224	59,402	18,566	13,949	44,100	-121,124	3	44,629	17,366
4	1200	820	166,044	59,104	19,397	13,249	57,348	-108,695	4	40,369	18,197
5	1200	745	166,789	58,809	20,265	12,583	69,932	-96,857	5	36,516	19,065
6	1200	677	167,466	58,515	21,172	11,951	81,883	-85,584	6	33,030	19,972
7	1200	616	168,082	58,222	22,120	11,351	93,234	-74,848	7	29,877	20,920
8	1200	560	168,642	57,931	23,110	10,781	104,014	-64,627	8	27,025	21,910
9	1200	509	169,151	57,642	24,144	10,239	114,254	-54,897	9	24,446	22,944
10	1200	463	169,613	57,353	25,224	9,725	123,979	-45,635	10	22,112	24,024
11	1200	421	170,034	57,067	26,353	9,237	133,215	-36,819	11	20,001	25,153
12	1200	382	170,416	56,781	27,532	8,773	141,988	-28,429	12	18,092	26,332
13	1200	348	170,764	56,497	28,764	8,332	150,320	-20,444	13	16,365	27,564
14	1200	316	171,080	56,215	30,051	7,913	158,233	-12,847	14	14,803	28,851
15	1200	287	171,367	55,934	31,396	7,516	165,749	-5,618	15	13,390	30,196
16	1200	261	171,628	55,654	32,801	7,139	172,888	1,259	FALSE	12,112	31,601
17	1200	237	171,866	55,376	34,269	6,780	179,668	7,802	FALSE	10,956	33,069
18	1200	216	172,082	55,099	35,803	6,439	186,107	14,025	FALSE	9,910	34,603
19	1200	196	172,278	54,823	37,405	6,116	192,223	19,945	FALSE	8,964	36,205
20	1200	178	172,456	54,549	39,079	5,809	198,032	25,576	FALSE	8,108	37,879
21	1200	162	172,618	54,277	40,827	5,517	203,549	30,931	FALSE	7,334	39,627
22	1200	147	172,766	54,005	42,654	5,240	208,789	36,023	FALSE	6,634	41,454
23	1200	134	172,900	53,735	44,563	4,977	213,766	40,866	FALSE	6,001	43,363
24	1200	122	173,022	53,467	46,557	4,727	218,492	45,471	FALSE	5,428	45,357
25	1200	111	173,132	53,199	48,641	4,489	222,982	49,849	FALSE	4,910	47,441
Total	**Discounted total cost =**	173,132		1,413,357			**NPV=**	49,849	**Discounted total electricity generated=**	524,900	
										IRR=	13.03%

No Carbon Tax Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	162,240	162,240								-162,240
1	1200	1,121	163,361	60,000	15,750	14,720	14,720	-148,642	1	56,075	14,550
2	1200	1,048	164,410	59,700	16,455	14,372	29,092	-135,318	2	52,144	15,255
3	1200	980	165,389	59,402	17,191	14,033	43,125	-122,264	3	48,489	15,991
4	1200	915	166,305	59,104	17,960	13,702	56,827	-109,478	4	45,091	16,760
5	1200	856	167,160	58,809	18,764	13,379	70,206	-96,955	5	41,930	17,564
6	1200	800	167,960	58,515	19,604	13,063	83,268	-84,691	6	38,991	18,404
7	1200	747	168,707	58,222	20,481	12,755	96,023	-72,684	7	36,258	19,281
8	1200	698	169,406	57,931	21,398	12,454	108,477	-60,929	8	33,717	20,198
9	1200	653	170,058	57,642	22,355	12,160	120,637	-49,422	9	31,353	21,155
10	1200	610	170,668	57,353	23,356	11,873	132,509	-38,159	10	29,156	22,156
11	1200	570	171,238	57,067	24,401	11,593	144,102	-27,136	11	27,112	23,201
12	1200	533	171,771	56,781	25,493	11,319	155,421	-16,350	12	25,212	24,293
13	1200	498	172,269	56,497	26,634	11,052	166,473	-5,796	13	23,444	25,434
14	1200	465	172,735	56,215	27,825	10,791	177,264	4,530	FALSE	21,801	26,625
15	1200	435	173,169	55,934	29,071	10,537	187,801	14,631	FALSE	20,273	27,871
16	1200	406	173,576	55,654	30,372	10,288	198,089	24,513	FALSE	18,852	29,172
17	1200	380	173,956	55,376	31,731	10,045	208,134	34,178	FALSE	17,531	30,531
18	1200	355	174,311	55,099	33,151	9,808	217,942	43,631	FALSE	16,302	31,951
19	1200	332	174,643	54,823	34,634	9,577	227,518	52,876	FALSE	15,159	33,434
20	1200	310	174,953	54,549	36,184	9,351	236,869	61,916	FALSE	14,097	34,984
21	1200	290	175,243	54,277	37,803	9,130	245,999	70,756	FALSE	13,109	36,603
22	1200	271	175,513	54,005	39,495	8,915	254,914	79,400	FALSE	12,190	38,295
23	1200	253	175,767	53,735	41,262	8,704	263,618	87,851	FALSE	11,335	40,062
24	1200	237	176,003	53,467	43,109	8,499	272,116	96,113	FALSE	10,541	41,909
25	1200	221	176,224	53,199	45,038	8,298	280,415	104,190	FALSE	9,802	43,838
Total	Discounted total cost =	176,224		1,413,357			NPV=	104,190	Discounted total electricity generated=	669,961	
										IRR=	12.06%

Depreciation Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	162,240	162,240			81,120						-162,240
1	1200	1,121	163,361	60,000	15,750	1,217	15,857	15,857	-147,505	1	56,075	15,767
2	1200	1,048	164,410	59,700	16,455	1,217	15,435	31,292	-133,118	2	52,144	16,472
3	1200	980	165,389	59,402	17,191	1,217	15,026	46,318	-119,071	3	48,489	17,208
4	1200	915	166,305	59,104	17,960	1,217	14,630	60,949	-105,356	4	45,091	17,977
5	1200	856	167,160	58,809	18,764	1,217	14,246	75,195	-91,966	5	41,930	18,781
6	1200	800	167,960	58,515	19,604	1,217	13,874	89,068	-78,891	6	38,991	19,621
7	1200	747	168,707	58,222	20,481	1,217	13,512	102,581	-66,126	7	36,258	20,498
8	1200	698	169,406	57,931	21,398	1,217	13,162	115,743	-53,663	8	33,717	21,415
9	1200	653	170,058	57,642	22,355	1,217	12,822	128,564	-41,494	9	31,353	22,372
10	1200	610	170,668	57,353	23,356	1,217	12,491	141,056	-29,613	10	29,156	23,372
11	1200	570	171,238	57,067	24,401	1,217	12,171	153,226	-18,012	11	27,112	24,418
12	1200	533	171,771	56,781	25,493	1,217	11,859	165,086	-6,685	12	25,212	25,510
13	1200	498	172,269	56,497	26,634	1,217	11,557	176,643	4,374	FALSE	23,444	26,650
14	1200	465	172,735	56,215	27,825	1,217	11,263	187,906	15,171	FALSE	21,801	27,842
15	1200	435	173,169	55,934	29,071	1,217	10,978	198,883	25,714	FALSE	20,273	29,087
16	1200	406	173,576	55,654	30,372	1,217	10,700	209,583	36,007	FALSE	18,852	30,388
17	1200	380	173,956	55,376	31,731	1,217	10,430	220,014	46,058	FALSE	17,531	31,747
18	1200	355	174,311	55,099	33,151	1,217	10,168	230,182	55,871	FALSE	16,302	33,167
19	1200	332	174,643	54,823	34,634	1,217	9,913	240,095	65,452	FALSE	15,159	34,651
20	1200	310	174,953	54,549	36,184	1,217	9,665	249,760	74,807	FALSE	14,097	36,201
21	1200	290	175,243	54,277	37,803		9,130	258,890	83,647	FALSE	13,109	36,603
22	1200	271	175,513	54,005	39,495		8,915	267,804	92,291	FALSE	12,190	38,295
23	1200	253	175,767	53,735	41,262		8,704	276,508	100,742	FALSE	11,335	40,062
24	1200	237	176,003	53,467	43,109		8,499	285,007	109,004	FALSE	10,541	41,909
25	1200	221	176,224	53,199	45,038		8,298	293,305	117,081	FALSE	9,802	43,838
Total	**Discounted total cost =**	176,224		1,413,357				**NPV=**	117,081	**Discounted total electricity generated=**	669,961	
											IRR=	12.71%

SRECs Scenario

Year	Capital and Fixed O&M Cost $	Small Renewable Energy Credits	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	995	125,425	125,425			81,120						-125,425
1	1200		1,121	126,546	60,000	15,750	1,217	15,857	15,857	-110,690	1	56,075	15,767
2	1200		1,048	127,595	59,700	16,455	1,217	15,435	31,292	-96,303	2	52,144	16,472
3	1200		980	128,574	59,402	17,191	1,217	15,026	46,318	-82,256	3	48,489	17,208
4	1200		915	129,490	59,104	17,960	1,217	14,630	60,949	-68,541	4	45,091	17,977
5	1200		856	130,345	58,809	18,764	1,217	14,246	75,195	-55,151	5	41,930	18,781
6	1200		800	131,145	58,515	19,604	1,217	13,874	89,068	-42,076	6	38,991	19,621
7	1200		747	131,892	58,222	20,481	1,217	13,512	102,581	-29,311	7	36,258	20,498
8	1200		698	132,591	57,931	21,398	1,217	13,162	115,743	-16,848	8	33,717	21,415
9	1200		653	133,243	57,642	22,355	1,217	12,822	128,564	-4,679	9	31,353	22,372
10	1200		610	133,853	57,353	23,356	1,217	12,491	141,056	7,202	FALSE	29,156	23,372
11	1200		570	134,423	57,067	24,401	1,217	12,171	153,226	18,803	FALSE	27,112	24,418
12	1200		533	134,956	56,781	25,493	1,217	11,859	165,086	30,130	FALSE	25,212	25,510
13	1200		498	135,454	56,497	26,634	1,217	11,557	176,643	41,189	FALSE	23,444	26,650
14	1200		465	135,920	56,215	27,825	1,217	11,263	187,906	51,986	FALSE	21,801	27,842
15	1200		435	136,354	55,934	29,071	1,217	10,978	198,883	62,529	FALSE	20,273	29,087
16	1200		406	136,761	55,654	30,372	1,217	10,700	209,583	72,822	FALSE	18,852	30,388
17	1200		380	137,141	55,376	31,731	1,217	10,430	220,014	82,873	FALSE	17,531	31,747
18	1200		355	137,496	55,099	33,151	1,217	10,168	230,182	92,686	FALSE	16,302	33,167
19	1200		332	137,828	54,823	34,634	1,217	9,913	240,095	102,267	FALSE	15,159	34,651
20	1200		310	138,138	54,549	36,184	1,217	9,665	249,760	111,622	FALSE	14,097	36,201
21	1200		290	138,428	54,277	37,803		9,130	258,890	120,462	FALSE	13,109	36,603
22	1200		271	138,698	54,005	39,495		8,915	267,804	129,106	FALSE	12,190	38,295
23	1200		253	138,952	53,735	41,262		8,704	276,508	137,557	FALSE	11,335	40,062
24	1200		237	139,188	53,467	43,109		8,499	285,007	145,819	FALSE	10,541	41,909
25	1200		221	139,409	53,199	45,038		8,298	293,305	153,896	FALSE	9,802	43,838
Total	**Discounted total cost =**		139,409		1,413,357				**NPV=**	153,896	**Discounted total electricity generated=**	669961.317	
												IRR=	16.13%

Feed-in Scenario

Year	Capital and Fixed O&M Cost $	Small Renewable Energy Credits	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity used onsite kWh	Electricity Cost saved $	Feed-in Cost saved $	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	162240	995	125,425	125,425					81,120						-125,425
1	1200		1,121	126,546	60,000	54,000	14,175	480	1,217	14,833	14,833	-111,713	1	56,075	14,672
2	1200		1,048	127,595	59,700	53,700	14,801	480	1,217	14,410	29,243	-98,351	2	52,144	15,298
3	1200		980	128,574	59,402	53,402	15,455	480	1,217	14,001	43,244	-85,330	3	48,489	15,952
4	1200		915	129,490	59,104	53,104	16,137	480	1,217	13,605	56,850	-72,640	4	45,091	16,634
5	1200		856	130,345	58,809	52,809	16,850	480	1,217	13,223	70,073	-60,272	5	41,930	17,347
6	1200		800	131,145	58,515	52,515	17,594	480	1,217	12,854	82,927	-48,218	6	38,991	18,091
7	1200		747	131,892	58,222	52,222	18,371	480	1,217	12,497	95,424	-36,468	7	36,258	18,867
8	1200		698	132,591	57,931	51,931	19,182	480	1,217	12,151	107,575	-25,015	8	33,717	19,678
9	1200		653	133,243	57,642	51,642	20,028	480	1,217	11,817	119,392	-13,851	9	31,353	20,525
10	1200		610	133,853	57,353	51,353	20,912	480	1,217	11,493	130,886	-2,968	10	29,156	21,409
11	1200		570	134,423	57,067	51,067	21,835	480	1,217	11,180	142,066	7,642	FALSE	27,112	22,332
12	1200		533	134,956	56,781	50,781	22,799	480	1,217	10,876	152,942	17,986	FALSE	25,212	23,296
13	1200		498	135,454	56,497	50,497	23,805	480	1,217	10,582	163,524	28,070	FALSE	23,444	24,302
14	1200		465	135,920	56,215	50,215	24,856	480	1,217	10,297	173,822	37,902	FALSE	21,801	25,352
15	1200		435	136,354	55,934	49,934	25,952	480	1,217	10,021	183,843	47,489	FALSE	20,273	26,449
16	1200		406	136,761	55,654	49,654	27,097	480	1,217	9,754	193,597	56,836	FALSE	18,852	27,594
17	1200		380	137,141	55,376	49,376	28,293	480	1,217	9,494	203,091	65,950	FALSE	17,531	28,789
18	1200		355	137,496	55,099	49,099	29,541	480	1,217	9,242	212,333	74,837	FALSE	16,302	30,037
19	1200		332	137,828	54,823	48,823	30,844	480	1,217	8,998	221,330	83,503	FALSE	15,159	31,340
20	1200		310	138,138	54,549	48,549	32,204	480	1,217	8,761	230,091	91,953	FALSE	14,097	32,701
21	1200		290	138,428	54,277	48,277	33,624	480		8,237	238,328	99,900	FALSE	13,109	32,904
22	1200		271	138,698	54,005	48,005	35,107	480		8,032	246,360	107,661	FALSE	12,190	34,387
23	1200		253	138,952	53,735	47,735	36,655	480		7,834	254,193	115,242	FALSE	11,335	35,935
24	1200		237	139,188	53,467	47,467	38,271	480		7,640	261,833	122,645	FALSE	10,541	37,551
25	1200		221	139,409	53,199	47,199	39,958	480		7,451	269,284	129,875	FALSE	9,802	39,238
Total	**Discounted total cost =**		139,409		1,413,357						**NPV=**	129,875	**Discounted total electricity generated=**	669,961	
														IRR=	14.94%

Comparison of NPVs							
Year	NPV 7%	NPV 4%	NPV 10%	NPV - No Carbon Tax	NPV- Depreciation	NPV- SRECs	NPV - Feed-in
1	-147464	-147038	-147867	-148642	-147505	-110690	-111713
2	-132990	-131717	-134172	-135318	-133118	-96303	-98351
3	-118814	-116278	-121124	-122264	-119071	-82256	-85330
4	-104932	-100723	-108695	-109478	-105356	-68541	-72640
5	-91338	-85053	-96857	-96955	-91966	-55151	-60272
6	-78030	-69269	-85584	-84691	-78891	-42076	-48218
7	-65002	-53371	-74848	-72684	-66126	-29311	-36468
8	-52251	-37362	-64627	-60929	-53663	-16848	-25015
9	-39771	-21242	-54897	-49422	-41494	-4679	-13851
10	-27558	-5013	-45635	-38159	-29613	7202	-2968
11	-15608	11326	-36819	-27136	-18012	18803	7642
12	-3916	27773	-28429	-16350	-6685	30130	17986
13	7522	44328	-20444	-5796	4374	41189	28070
14	18711	60989	-12847	4530	15171	51986	37902
15	29655	77756	-5618	14631	25714	62529	47489
16	40360	94628	1259	24513	36007	72822	56836
17	50829	111604	7802	34178	46058	82873	65950
18	61066	128685	14025	43631	55871	92686	74837
19	71077	145870	19945	52876	65452	102267	83503
20	80866	163157	25576	61916	74807	111622	91953
21	90436	180547	30931	70756	83647	120462	99900
22	99793	198039	36023	79400	92291	129106	107661
23	108940	215632	40866	87851	100742	137557	115242
24	117883	233327	45471	96113	109004	145819	122645
25	126623	251123	49849	104190	117081	153896	129875

Case study 2: LRECs calculation of Westfield Solar Farm PV project

PV System Size & Generation

The proposed Stage-2 PV system has maximum capacity of around 294 new modules to the West, and 258 new modules to East of the existing Stage-1 array. This makes a total capacity of 129.72kW for the new Stage-2 PV system.

Stage-2 – Westfield Solar Farm

Estimated Number of PV Modules:	552
Rated PV Power:	129.72 kW
Annual kWh Generation:	176,624 kWh
% of Average Annual Site Consumption:	10%
Annual Greenhouse Gas Savings (tonnes CO_2/year):	174.4 tCO_2/year

Assumptions:

- The base year 0 for the constant dollar present value is set to 2014.
- A discount rate is 7% and sensibility analysis rates are 4% and 10%, as recommended by the NSW Treasury (2007).
- The full lifecycle of PV plant is assumed to be 25 years.
- Assume all PV arrays are north-facing, inclined at latitude angle and installed on a roof area of a commercial building that generates optimum electricity to be fully utilised locally during office hours.
- Carbon price is included in electricity price for the Basic, Low and High Discount Rate scenarios, but excluded from all other scenarios.
- The depreciation value of the PV plant is half of the capital cost, which is to be written-off in 20 years (common practice in councils).
- Corporate tax rate is 30% and GST is not included in the costs.
- When Renewable Energy Credits are included, the prices are assumed to be $37 per SREC and $39 per LREC.
- The price range of the feed-in tariff is adopted from IPART.
- The transmission or interconnection costs are excluded.

Solar Photovoltaic (PV) Input Module

Inputs	Values	Units	Remarks
Plant Capacity (Net)	130	kW	
Number of Solar Panels	552		Each panel = 235 Watt
Capital Cost (Installed cost)	**3380**	$/kW	Cost for Installment of Panels / per KW
Total Capital Cost	**439400**	2014 dollar	Total Cost of installing panels
Fixed O&M cost	**25**	$/kW/year	Operation and Maintenance Cost including invertor (BREE 2013)
Total O&M cost	**3250**	2014 $/year	
Annual Electricity Output	176.624	MWh/year	NREL PVWatts Calculator = 169,427 kWh/year
Annual Production Degradation	0.5	%	Decrease in Production per annum range 0.01-1%
Electricity Price (with Carbon Tax)	27	cents/kWh	Market price of electricity for council including carbon tax
Electricity Price (ex Carbon Tax)	25	cents/kWh	Market price of electricity for council excluding carbon tax
Electricity Price annual increase rate	5	%	Assumed annual increased rate
Discount Rate	7	%	Constant dollar discount rate without inflation from Treasury Report
Low Discount Rate	4	%	
High Discount Rate	10	%	
Operating years	25	years	Flexible, potentially 30 years
Percentage of PV to Total Capital Cost	50	%	
Depreciation Amount	219700	Dollar	Assume PV panel price to be 50% of total capital cost
Depreciation Rate	5	%	Assume PV panel capital cost to be written off in 20 years
Corporate Tax Rate	30	%	Corporate tax
Number of SRECs	0	RECs or STCs	https://www.rec-registry.gov.au/sguCalculatorResult.shtml
Price of each SRECs	37	Dollar	Assumed market price per SREC and are taken as initial discount from price
Price of each LRECs	39	Dollar	Assumed market price per Large Renewable Energy Credit (LREC)
Feed-in percentage of PV power	10	%	
Feed-in Tariff/kWh	8	cents/kWh	Price from IPART

Output Module - Basic Scenario

Outputs	Values	Units
Net Present Value (NPV)	414,229	Dollar
Levelised Cost of Electricity (LCOE)	0.24	Dollar/kWh
Discounted Payback Period (DPP)	12	years
Internal Rate of Return (IRR)	14.13%	

Output Module - Low Discount Rate Scenario

Outputs	Values	Units
Net Present Value (NPV)	781,844	Dollar
Levelised Cost of Electricity (LCOE)	0.19	Dollar/kWh
Discounted Payback Period (DPP)	10	years
Internal Rate of Return (IRR)	14.13%	

Output Module - High Discount Rate Scenario

Outputs	Values	Units
Net Present Value (NPV)	187,498	Dollar
Levelised Cost of Electricity (LCOE)	0.30	Dollar/kWh
Discounted Payback Period (DPP)	14	years
Internal Rate of Return (IRR)	14.13%	

Output Module - No Carbon Tax Scenario

Outputs	Values	Units
Net Present Value (NPV)	348,192	Dollar
Levelised Cost of Electricity (LCOE)	0.24	Dollar/kWh
Discounted Payback Period (DPP)	13	years
Internal Rate of Return (IRR)	13.11%	

Output Module - Depreciation Scenario

Outputs	Values	Units
Net Present Value (NPV)	383,104	Dollar
Levelised Cost of Electricity (LCOE)	0.24	Dollar/kWh
Discounted Payback Period (DPP)	12	years
Internal Rate of Return (IRR)	13.76%	%

Output Module - LRECs Scenario

Outputs	Values	Units
Net Present Value (NPV)	459,762	Dollar
Levelised Cost of Electricity (LCOE)	0.24	Dollar/kWh
Discounted Payback Period (DPP)	11	years
Internal Rate of Return (IRR)	13.94%	

Output Module - Feed-in Scenario

Outputs	Values	Units
Net Present Value (NPV)	389,049	Dollar
Levelised Cost of Electricity (LCOE)	0.24	Dollar/kWh
Discounted Payback Period (DPP)	11	years
Internal Rate of Return (IRR)	14.07%	

Basic Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400								-439,400
1	3250	3,037	442,437	176,624	50,073	46,797	46,797	-395,640	1	165,069	46,823
2	3250	2,839	445,276	175,741	52,314	45,693	92,490	-352,786	2	153,499	49,064
3	3250	2,653	447,929	174,862	54,655	44,615	137,104	-310,825	3	142,740	51,405
4	3250	2,479	450,408	173,988	57,101	43,562	180,666	-269,742	4	132,735	53,851
5	3250	2,317	452,726	173,118	59,656	42,534	223,200	-229,526	5	123,431	56,406
6	3250	2,166	454,891	172,252	62,325	41,530	264,730	-190,161	6	114,779	59,075
7	3250	2,024	456,915	171,391	65,114	40,550	305,280	-151,635	7	106,734	61,864
8	3250	1,892	458,807	170,534	68,028	39,593	344,873	-113,934	8	99,252	64,778
9	3250	1,768	460,575	169,681	71,073	38,659	383,532	-77,043	9	92,295	67,823
10	3250	1,652	462,227	168,833	74,253	37,746	421,278	-40,949	10	85,826	71,003
11	3250	1,544	463,771	167,989	77,576	36,856	458,134	-5,637	11	79,810	74,326
12	3250	1,443	465,214	167,149	81,047	35,986	494,120	28,906	FALSE	74,216	77,797
13	3250	1,349	466,562	166,313	84,674	35,137	529,257	62,694	FALSE	69,014	81,424
14	3250	1,260	467,823	165,482	88,463	34,308	563,564	95,742	FALSE	64,177	85,213
15	3250	1,178	469,001	164,654	92,422	33,498	597,062	128,062	FALSE	59,678	89,172
16	3250	1,101	470,102	163,831	96,558	32,708	629,770	159,668	FALSE	55,495	93,308
17	3250	1,029	471,130	163,012	100,879	31,936	661,706	190,575	FALSE	51,605	97,629
18	3250	962	472,092	162,197	105,393	31,182	692,888	220,796	FALSE	47,988	102,143
19	3250	899	472,991	161,386	110,110	30,446	723,334	250,343	FALSE	44,625	106,860
20	3250	840	473,831	160,579	115,037	29,728	753,062	279,231	FALSE	41,497	111,787
21	3250	785	474,615	159,776	120,185	29,026	782,088	307,473	FALSE	38,588	116,935
22	3250	734	475,349	158,977	125,563	28,341	810,429	335,080	FALSE	35,883	122,313
23	3250	686	476,035	158,182	131,182	27,672	838,102	362,067	FALSE	33,368	127,932
24	3250	641	476,675	157,391	137,053	27,019	865,121	388,446	FALSE	31,029	133,803
25	3250	599	477,274	156,604	143,186	26,382	891,503	414,229	FALSE	28,854	139,936
Total	**Discounted total cost =**	477,274		4,160,546			**NPV=**	414,229	**Discounted total electricity generated=**	1,972,187	
										IRR=	14.13%

Low Discount Rate Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400								-439,400
1	3250	3,125	442,525	176,624	50,073	48,147	48,147	-394,378	1	169,831	46,823
2	3250	3,005	445,530	175,741	52,314	48,367	96,514	-349,016	2	162,482	49,064
3	3250	2,889	448,419	174,862	54,655	48,588	145,102	-303,317	3	155,452	51,405
4	3250	2,778	451,197	173,988	57,101	48,810	193,912	-257,286	4	148,726	53,851
5	3250	2,671	453,868	173,118	59,656	49,033	242,944	-210,924	5	142,290	56,406
6	3250	2,569	456,437	172,252	62,325	49,257	292,201	-164,236	6	136,134	59,075
7	3250	2,470	458,907	171,391	65,114	49,482	341,682	-117,224	7	130,243	61,864
8	3250	2,375	461,281	170,534	68,028	49,708	391,390	-69,891	8	124,608	64,778
9	3250	2,283	463,565	169,681	71,073	49,935	441,325	-22,240	9	119,216	67,823
10	3250	2,196	465,760	168,833	74,253	50,163	491,487	25,727	FALSE	114,058	71,003
11	3250	2,111	467,872	167,989	77,576	50,392	541,879	74,008	FALSE	109,122	74,326
12	3250	2,030	469,901	167,149	81,047	50,622	592,501	122,600	FALSE	104,401	77,797
13	3250	1,952	471,853	166,313	84,674	50,853	643,354	171,501	FALSE	99,883	81,424
14	3250	1,877	473,730	165,482	88,463	51,085	694,440	220,710	FALSE	95,562	85,213
15	3250	1,805	475,535	164,654	92,422	51,319	745,758	270,224	FALSE	91,427	89,172
16	3250	1,735	477,270	163,831	96,558	51,553	797,312	320,042	FALSE	87,471	93,308
17	3250	1,668	478,938	163,012	100,879	51,789	849,100	370,162	FALSE	83,686	97,629
18	3250	1,604	480,543	162,197	105,393	52,025	901,125	420,583	FALSE	80,065	102,143
19	3250	1,543	482,085	161,386	110,110	52,263	953,388	471,303	FALSE	76,601	106,860
20	3250	1,483	483,569	160,579	115,037	52,501	1,005,889	522,321	FALSE	73,286	111,787
21	3250	1,426	484,995	159,776	120,185	52,741	1,058,631	573,636	FALSE	70,115	116,935
22	3250	1,371	486,366	158,977	125,563	52,982	1,111,613	625,247	FALSE	67,081	122,313
23	3250	1,319	487,685	158,182	131,182	53,224	1,164,837	677,152	FALSE	64,179	127,932
24	3250	1,268	488,953	157,391	137,053	53,467	1,218,304	729,351	FALSE	61,402	133,803
25	3250	1,219	490,172	156,604	143,186	53,711	1,272,015	781,844	FALSE	58,745	139,936
Total	Discounted total cost =	490,172		4,160,546			NPV=	781,844	Discounted total electricity generated=	2,626,063	
										IRR=	14.13%

High Discount Rate Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400								-439,400
1	3250	2,955	442,355	176,624	50,073	45,521	45,521	-396,834	1	160,567	46,823
2	3250	2,686	445,040	175,741	52,314	43,234	88,755	-356,285	2	145,240	49,064
3	3250	2,442	447,482	174,862	54,655	41,063	129,818	-317,664	3	131,377	51,405
4	3250	2,220	449,702	173,988	57,101	39,000	168,819	-280,884	4	118,836	53,851
5	3250	2,018	451,720	173,118	59,656	37,042	205,860	-245,860	5	107,493	56,406
6	3250	1,835	453,555	172,252	62,325	35,181	241,041	-212,513	6	97,232	59,075
7	3250	1,668	455,222	171,391	65,114	33,414	274,455	-180,767	7	87,951	61,864
8	3250	1,516	456,739	170,534	68,028	31,736	306,191	-150,548	8	79,555	64,778
9	3250	1,378	458,117	169,681	71,073	30,142	336,332	-121,784	9	71,961	67,823
10	3250	1,253	459,370	168,833	74,253	28,628	364,960	-94,410	10	65,092	71,003
11	3250	1,139	460,509	167,989	77,576	27,190	392,150	-68,359	11	58,879	74,326
12	3250	1,036	461,544	167,149	81,047	25,824	417,974	-43,570	12	53,259	77,797
13	3250	941	462,486	166,313	84,674	24,527	442,501	-19,984	13	48,175	81,424
14	3250	856	463,342	165,482	88,463	23,295	465,797	2,455	FALSE	43,576	85,213
15	3250	778	464,120	164,654	92,422	22,125	487,922	23,802	FALSE	39,417	89,172
16	3250	707	464,827	163,831	96,558	21,014	508,936	44,109	FALSE	35,654	93,308
17	3250	643	465,470	163,012	100,879	19,958	528,894	63,424	FALSE	32,251	97,629
18	3250	585	466,055	162,197	105,393	18,956	547,850	81,795	FALSE	29,173	102,143
19	3250	531	466,586	161,386	110,110	18,004	565,854	99,268	FALSE	26,388	106,860
20	3250	483	467,069	160,579	115,037	17,100	582,953	115,884	FALSE	23,869	111,787
21	3250	439	467,508	159,776	120,185	16,241	599,194	131,686	FALSE	21,591	116,935
22	3250	399	467,908	158,977	125,563	15,425	614,619	146,711	FALSE	19,530	122,313
23	3250	363	468,270	158,182	131,182	14,650	629,269	160,999	FALSE	17,665	127,932
24	3250	330	468,600	157,391	137,053	13,914	643,183	174,583	FALSE	15,979	133,803
25	3250	300	468,900	156,604	143,186	13,215	656,399	187,498	FALSE	14,454	139,936
Total	Discounted total cost =	468,900		4,160,546			NPV=	187,498	Discounted total electricity generated=	1,545,165	
										IRR=	14.13%

No Carbon Tax Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Discounted Electricity Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400								-439,400
1	3250	3,037	442,437	176,624	46,364	43,331	43,331	-399,107	1	165,069	43,114
2	3250	2,839	445,276	175,741	48,439	42,308	85,639	-359,637	2	153,499	45,189
3	3250	2,653	447,929	174,862	50,606	41,310	126,949	-320,981	3	142,740	47,356
4	3250	2,479	450,408	173,988	52,871	40,335	167,283	-283,125	4	132,735	49,621
5	3250	2,317	452,726	173,118	55,237	39,383	206,667	-246,059	5	123,431	51,987
6	3250	2,166	454,891	172,252	57,709	38,454	245,120	-209,771	6	114,779	54,459
7	3250	2,024	456,915	171,391	60,291	37,546	282,666	-174,249	7	106,734	57,041
8	3250	1,892	458,807	170,534	62,989	36,660	319,327	-139,480	8	99,252	59,739
9	3250	1,768	460,575	169,681	65,808	35,795	355,122	-105,453	9	92,295	62,558
10	3250	1,652	462,227	168,833	68,753	34,950	390,072	-72,154	10	85,826	65,503
11	3250	1,544	463,771	167,989	71,829	34,126	424,198	-39,573	11	79,810	68,579
12	3250	1,443	465,214	167,149	75,044	33,320	457,518	-7,695	12	74,216	71,794
13	3250	1,349	466,562	166,313	78,402	32,534	490,052	23,490	FALSE	69,014	75,152
14	3250	1,260	467,823	165,482	81,911	31,766	521,819	53,996	FALSE	64,177	78,661
15	3250	1,178	469,001	164,654	85,576	31,017	552,835	83,835	FALSE	59,678	82,326
16	3250	1,101	470,102	163,831	89,406	30,285	583,120	113,019	FALSE	55,495	86,156
17	3250	1,029	471,130	163,012	93,407	29,570	612,690	141,560	FALSE	51,605	90,157
18	3250	962	472,092	162,197	97,586	28,872	641,563	169,471	FALSE	47,988	94,336
19	3250	899	472,991	161,386	101,953	28,191	669,754	196,763	FALSE	44,625	98,703
20	3250	840	473,831	160,579	106,516	27,526	697,279	223,449	FALSE	41,497	103,266
21	3250	785	474,615	159,776	111,282	26,876	724,156	249,540	FALSE	38,588	108,032
22	3250	734	475,349	158,977	116,262	26,242	750,397	275,048	FALSE	35,883	113,012
23	3250	686	476,035	158,182	121,465	25,623	776,020	299,986	FALSE	33,368	118,215
24	3250	641	476,675	157,391	126,901	25,018	801,038	324,363	FALSE	31,029	123,651
25	3250	599	477,274	156,604	132,579	24,428	825,466	348,192	FALSE	28,854	129,329
Total	**Discounted total cost =**	**477,274**		4,160,546			**NPV=**	348,192	**Discounted total electricity generated=**	**1,972,187**	
										IRR=	13.11%

Depreciation Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400			219,700						-439,400
1	3250	3,037	442,437	176,624	46,364	3,296	46,411	46,411	-396,027	1	165,069	46,409
2	3250	2,839	445,276	175,741	48,439	3,296	45,187	91,597	-353,679	2	153,499	48,484
3	3250	2,653	447,929	174,862	50,606	3,296	44,000	135,597	-312,332	3	142,740	50,652
4	3250	2,479	450,408	173,988	52,871	3,296	42,849	178,446	-271,962	4	132,735	52,916
5	3250	2,317	452,726	173,118	55,237	3,296	41,733	220,179	-232,547	5	123,431	55,282
6	3250	2,166	454,891	172,252	57,709	3,296	40,650	260,828	-194,063	6	114,779	57,754
7	3250	2,024	456,915	171,391	60,291	3,296	39,599	300,427	-156,488	7	106,734	60,337
8	3250	1,892	458,807	170,534	62,989	3,296	38,578	339,005	-119,802	8	99,252	63,035
9	3250	1,768	460,575	169,681	65,808	3,296	37,588	376,593	-83,982	9	92,295	65,853
10	3250	1,652	462,227	168,833	68,753	3,296	36,626	413,219	-49,008	10	85,826	68,798
11	3250	1,544	463,771	167,989	71,829	3,296	35,691	448,910	-14,861	11	79,810	71,875
12	3250	1,443	465,214	167,149	75,044	3,296	34,784	483,694	18,480	FALSE	74,216	75,089
13	3250	1,349	466,562	166,313	78,402	3,296	33,902	517,595	51,033	FALSE	69,014	78,448
14	3250	1,260	467,823	165,482	81,911	3,296	33,044	550,639	82,817	FALSE	64,177	81,956
15	3250	1,178	469,001	164,654	85,576	3,296	32,211	582,851	113,850	FALSE	59,678	85,622
16	3250	1,101	470,102	163,831	89,406	3,296	31,401	614,252	144,150	FALSE	55,495	89,451
17	3250	1,029	471,130	163,012	93,407	3,296	30,613	644,865	173,735	FALSE	51,605	93,452
18	3250	962	472,092	162,197	97,586	3,296	29,847	674,712	202,620	FALSE	47,988	97,632
19	3250	899	472,991	161,386	101,953	3,296	29,102	703,815	230,824	FALSE	44,625	101,999
20	3250	840	473,831	160,579	106,516	3,296	28,377	732,192	258,361	FALSE	41,497	106,561
21	3250	785	474,615	159,776	111,282		26,876	759,068	284,453	FALSE	38,588	108,032
22	3250	734	475,349	158,977	116,262		26,242	785,310	309,961	FALSE	35,883	113,012
23	3250	686	476,035	158,182	121,465		25,623	810,933	334,898	FALSE	33,368	118,215
24	3250	641	476,675	157,391	126,901		25,018	835,951	359,275	FALSE	31,029	123,651
25	3250	599	477,274	156,604	132,579		24,428	860,378	383,104	FALSE	28,854	129,329
Total	Discounted total cost =	477,274		4,160,546				NPV=	383,104	Discounted total electricity generated=	1,972,187	
											IRR=	13.76%

LRECs Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity Cost saved $	Large Renewable Energy Credits	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400				219,700						-439,400
1	3250	3,037	442,437	176,624	46,364	6,864	3,296	52,826	52,826	-389,612	1	165,069	53,273
2	3250	2,839	445,276	175,741	48,439	6,825	3,296	51,148	103,973	-341,303	2	153,499	48,484
3	3250	2,653	447,929	174,862	50,606	6,786	3,296	49,539	153,513	-294,416	3	142,740	50,652
4	3250	2,479	450,408	173,988	52,871	6,747	3,296	47,996	201,509	-248,900	4	132,735	52,916
5	3250	2,317	452,726	173,118	55,237	6,747	3,296	46,543	248,052	-204,674	5	123,431	55,282
6	3250	2,166	454,891	172,252	57,709	6,708	3,296	45,119	293,172	-161,720	6	114,779	57,754
7	3250	2,024	456,915	171,391	60,291	6,669	3,296	43,752	336,923	-119,992	7	106,734	60,337
8	3250	1,892	458,807	170,534	62,989	6,630	3,296	42,437	379,360	-79,447	8	99,252	63,035
9	3250	1,768	460,575	169,681	65,808	6,591	3,296	41,173	420,533	-40,042	9	92,295	65,853
10	3250	1,652	462,227	168,833	68,753	6,552	3,296	39,956	460,489	-1,737	10	85,826	68,798
11	3250	1,544	463,771	167,989	71,829	6,513	3,296	38,786	499,275	35,504	FALSE	79,810	71,875
12	3250	1,443	465,214	167,149	75,044	6,513	3,296	37,675	536,950	71,737	FALSE	74,216	75,089
13	3250	1,349	466,562	166,313	78,402	6,474	3,296	36,588	573,538	106,976	FALSE	69,014	78,448
14	3250	1,260	467,823	165,482	81,911	6,435	3,296	35,540	609,078	141,256	FALSE	64,177	81,956
15	3250	1,178	469,001	164,654	85,576	6,396	3,296	34,529	643,608	174,607	FALSE	59,678	85,622
16	3250	1,101	470,102	163,831	89,406	6,357	3,296	33,554	677,162	207,061	FALSE	55,495	89,451
17	3250	1,029	471,130	163,012	93,407	6,357	3,296	32,626	709,788	238,658	FALSE	51,605	93,452
18	3250	962	472,092	162,197	97,586	6,318	3,296	31,717	741,505	269,413	FALSE	47,988	97,632
19	3250	899	472,991	161,386	101,953	6,279	3,296	30,838	772,343	299,352	FALSE	44,625	101,999
20	3250	840	473,831	160,579	106,516	6,240	3,296	29,990	802,333	328,502	FALSE	41,497	106,561
21	3250	785	474,615	159,776	111,282	6,201		28,374	830,707	356,091	FALSE	38,588	108,032
22	3250	734	475,349	158,977	116,262	6,162		27,633	858,340	382,990	FALSE	35,883	113,012
23	3250	686	476,035	158,182	121,465	6,162		26,923	885,262	409,227	FALSE	33,368	118,215
24	3250	641	476,675	157,391	126,901	6,123		26,225	911,487	434,812	FALSE	31,029	123,651
25	3250	599	477,274	156,604	132,579	6,084		25,549	937,036	459,762	FALSE	28,854	129,329
Total	Discounted total cost =	477,274		4,160,546					NPV=	459,762	Discounted total electricity generated=	1,972,187	
												IRR=	13.94%

Feed-in Scenario

Year	Capital and Fixed O&M Cost $	Discounted Capital and Fixed O&M Cost $	Cumulative discounted Cost $	Electricity Output kWh/year	Electricity used onsite kWh	Electricity Cost saved $	Feed-in Cost saved $	Large Renewable Energy Credits	Depreciation Cost saved $	Discounted Total Cost saved $	Cumulative discounted Cost saved $	Discounted Operating Result $	Negative Operating Result	Discounted Electricity Output kWh	Annual cash-flow $
0	439400	439,400	439,400						219,700						-439,400
1	3250	3,037	442,437	176,624	158,962	41,727	1,413	6,864	3,296	49,813	49,813	-392,624	1	165,069	50,050
2	3250	2,839	445,276	175,741	158,078	43,570	1,413	6,825	3,296	48,130	97,943	-347,333	2	153,499	51,854
3	3250	2,653	447,929	174,862	157,200	45,495	1,413	6,786	3,296	46,520	144,463	-303,466	3	142,740	53,739
4	3250	2,479	450,408	173,988	156,325	47,504	1,413	6,747	3,296	44,980	189,443	-260,966	4	132,735	55,709
5	3250	2,317	452,726	173,118	155,456	49,601	1,413	6,747	3,296	43,533	232,975	-219,750	5	123,431	57,807
6	3250	2,166	454,891	172,252	154,590	51,791	1,413	6,708	3,296	42,118	275,093	-179,798	6	114,779	59,958
7	3250	2,024	456,915	171,391	153,729	54,078	1,413	6,669	3,296	40,762	315,856	-141,060	7	106,734	62,205
8	3250	1,892	458,807	170,534	152,872	56,465	1,413	6,630	3,296	39,462	355,318	-103,489	8	99,252	64,554
9	3250	1,768	460,575	169,681	152,019	58,958	1,413	6,591	3,296	38,215	393,533	-67,041	9	92,295	67,007
10	3250	1,652	462,227	168,833	151,171	61,560	1,413	6,552	3,296	37,018	430,552	-31,675	10	85,826	69,571
11	3250	1,544	463,771	167,989	150,326	64,277	1,413	6,513	3,296	35,869	466,421	2,650	FALSE	79,810	72,249
12	3250	1,443	465,214	167,149	149,487	67,114	1,413	6,513	3,296	34,782	501,203	35,989	FALSE	74,216	75,086
13	3250	1,349	466,562	166,313	148,651	70,076	1,413	6,474	3,296	33,719	534,922	68,360	FALSE	69,014	78,008
14	3250	1,260	467,823	165,482	147,819	73,168	1,413	6,435	3,296	32,697	567,619	99,797	FALSE	64,177	81,061
15	3250	1,178	469,001	164,654	146,992	76,396	1,413	6,396	3,296	31,714	599,334	130,333	FALSE	59,678	84,251
16	3250	1,101	470,102	163,831	146,169	79,767	1,413	6,357	3,296	30,768	630,102	160,000	FALSE	55,495	87,582
17	3250	1,029	471,130	163,012	145,349	83,286	1,413	6,357	3,296	29,869	659,971	188,840	FALSE	51,605	91,101
18	3250	962	472,092	162,197	144,534	86,960	1,413	6,318	3,296	28,991	688,962	216,870	FALSE	47,988	94,736
19	3250	899	472,991	161,386	143,723	90,795	1,413	6,279	3,296	28,144	717,105	244,115	FALSE	44,625	98,533
20	3250	840	473,831	160,579	142,916	94,800	1,413	6,240	3,296	27,327	744,433	270,602	FALSE	41,497	102,498
21	3250	785	474,615	159,776	142,114	98,981	1,413	6,201		25,744	770,177	295,561	FALSE	38,588	103,345
22	3250	734	475,349	158,977	141,315	103,346	1,413	6,162		25,036	795,213	319,864	FALSE	35,883	107,671
23	3250	686	476,035	158,182	140,520	107,902	1,413	6,162		24,360	819,573	343,538	FALSE	33,368	112,227
24	3250	641	476,675	157,391	139,729	112,660	1,413	6,123		23,696	843,269	366,594	FALSE	31,029	116,946
25	3250	599	477,274	156,604	138,942	117,627	1,413	6,084		23,054	866,323	389,049	FALSE	28,854	121,874
Total	Discounted total cost =	477,274		4,160,546							NPV=	389,049	Discounted total electricity generated=	1,972,187	
														IRR=	14.07%

Comparison of NPVs							
Year	NPV 7%	NPV 4%	NPV 10%	NPV - No Carbon Tax	NPV- Depreciation	NPV- LRECs	NPV - Feed-in
1	-395640	-394378	-396834	-399107	-396027	-389612	-392624
2	-352786	-349016	-356285	-359637	-353679	-341303	-347333
3	-310825	-303317	-317664	-320981	-312332	-294416	-303466
4	-269742	-257286	-280884	-283125	-271962	-248900	-260966
5	-229526	-210924	-245860	-246059	-232547	-204674	-219750
6	-190161	-164236	-212513	-209771	-194063	-161720	-179798
7	-151635	-117224	-180767	-174249	-156488	-119992	-141060
8	-113934	-69891	-150548	-139480	-119802	-79447	-103489
9	-77043	-22240	-121784	-105453	-83982	-40042	-67041
10	-40949	25727	-94410	-72154	-49008	-1737	-31675
11	-5637	74008	-68359	-39573	-14861	35504	2650
12	28906	122600	-43570	-7695	18480	71737	35989
13	62694	171501	-19984	23490	51033	106976	68360
14	95742	220710	2455	53996	82817	141256	99797
15	128062	270224	23802	83835	113850	174607	130333
16	159668	320042	44109	113019	144150	207061	160000
17	190575	370162	63424	141560	173735	238658	188840
18	220796	420583	81795	169471	202620	269413	216870
19	250343	471303	99268	196763	230824	299352	244115
20	279231	522321	115884	223449	258361	328502	270602
21	307473	573636	131686	249540	284453	356091	295561
22	335080	625247	146711	275048	309961	382990	319864
23	362067	677152	160999	299986	334898	409227	343538
24	388446	729351	174583	324363	359275	434812	366594
25	414229	781844	187498	348192	383104	459762	389049

Appendix C: Ethics approval and project consent letter

Subject	**Ethics Application 5201400296 Approved**
From	Faculty of Science Research Office
To	Dr Peter Davies
Cc	Professor Richie Howitt; Ms Cathi Humphrey-Hood; Miss Grace May Yung Cheung
Sent	Wednesday, 26 March 2014 10:37 AM

Dear Dr Davies,

RE: Ethics project entitled: "A study of local governments' challenges and processes in financing their greenhouse gas abatement initiatives"

Ref number: 5201400296

The Faculty of Science Human Research Ethics Sub-Committee has reviewed your application and granted approval, effective (26/03/2014). This email constitutes ethical approval only.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72.pdf.

The following personnel are authorised to conduct this research:

Dr Peter Davies
Professor Stefan Trueck
Ms Grace Cheung

NB. STUDENTS: IT IS YOUR RESPONSIBILITY TO KEEP A COPY OF THIS APPROVAL EMAIL TO SUBMIT WITH YOUR THESIS.

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 26 Mar 2015
Progress Report 2 Due: 26 Mar 2016
Progress Report 3 Due: 26 Mar 2017
Progress Report 4 Due: 26 Mar 2018
Final Report Due: 26 Mar 2019

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.

Progress reports and Final Reports are available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/
human_research_ethics/forms

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/
human_research_ethics/forms

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:
http://www.mq.edu.au/policy/

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/
human_research_ethics/policy

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have final approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of Final Approval to an external organisation as evidence that you have Final Approval, please do not hesitate to contact the Ethics Secretariat at the address below.

Please retain a copy of this email as this is your official notification of final ethics approval.

Yours sincerely,
Richie Howitt, Chair
Faculty of Science Human Ethics Committee Secretariat

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Chief Investigator: Dr Peter Davies
Chief Investigator: Prof Stefan Trueck
Student's Name: Ms. Grace Cheung

Participant Information and Consent Form

Name of Project: **A study of local governments' challenges and processes in financing their greenhouse gas abatement initiatives**

You are invited to participate in the Master of Research student project of '***A study of local governments' challenges and processes in financing their greenhouse gas abatement initiatives'***. The purpose of this study to investigate the decision making processes by local councils in Sydney behind alternative energy projects including the technical analysis and financial evaluation. This research aims to identify the challenges and barriers affecting the uptake of alternative energy projects and specifically how financial models and decision making processes are used. The outcome will identify effective frameworks that could be used by the local government sector to enhance future greenhouse gas abatement development programs.

The study is being conducted to meet the requirements of the Master of Research degree under the supervision of Dr Peter Davies, Lecturer, Department of Environment and Geography at the above contacts, and Prof Stefan Trueck, Professor, Department of Applied Finance and Actuarial Studies of Faculty of Business and Economics.

If you decide to participate, you and your financial manager or officer will be asked to undertake a survey questionnaire for qualitative and quantitative data on council's installed and planned energy efficiency and alternative energy capacity as well as their related information on internal financial evaluation and decision making processes. After the survey questionnaire, an interview of about 60 minutes each with environment and financial manager or officer on your council's position in climate change mitigation policy and what are the challenges and opportunities. At the same time any data in question from the survey would also be clarified in the interview.

If you agree, the interview will be audio-recorded to shorten the time with efficient flow of the interview and enable the researcher to have a good record of the information obtained for analysis. Otherwise you can elect to have the researcher take notes. The audio-recorded interview material will be destroyed at the conclusion of the project and during the project only the researcher has access to the data and to ensure their security they will be kept on standalone disk and locked away in a filing cabinet at researcher's home. It is not expected there will be any discomfort caused by the questions and no remuneration is associated with the project.

Any information or individual council details gathered in the course of the study are confidential, except as required by law. No individual council will be identified in any publication of the results without the council's approval. A summary of the results of the data can be made available to you on request via email to *grace.cheung@students.mq.edu.au.*

Participation in this study is entirely voluntary: you are not obliged to participate and if you decide to participate, you are free to withdraw at any time without having to give a reason and without consequence.

I, *(participant's name)* have read *(or, where appropriate, have had read to me)* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name:____
(Block letters)

Participant's Signature:________________________ Date:__________________

Investigator's Name:____
(Block letters)

Investigator's Signature: ____________________ __ Date:__________________

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

(INVESTIGATOR'S [OR PARTICIPANT'S] COPY)